[redacted]

ECKENFELDER INC.

ORIGINAL (Red)

HEALTH AND SAFETY CONTINGENCY PLAN
FOR
REMEDIAL DESIGN ACTIVITIES
SHOPE'S LANDFILL
GIRARD TOWNSHIP, PENNSYLVANIA

Prepared for:

LORD CORPORATION
Erie, Pennsylvania

Prepared by:

ECKENFELDER INC.
227 French Landing Drive
Nashville, Tennessee 37228
(615) 255-2288

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1.0 INTRODUCTION

1.1 SCOPE AND APPLICABILITY OF THE SITE HEALTH AND SAFETY CONTINGENCY PLAN

The scope of this Health and Safety Contingency Plan (HASCP) is to identify, evaluate, and control potential safety and health hazards, as well as to provide emergency response to accidents during Phase 1, Phase 2, and Phase 3 field operations at the Shope's Landfill, Girard Township, Pennsylvania. Phase 1 involves well installation, vapor extraction, and the use of monitoring probes during in situ vapor stripping field studies. Phase 2 involves groundwater recovery well installation and groundwater sampling. Phase 3 involves the sampling of individual groundwater components, groundwater composites, clarifier effluent, filter effluent, final effluent, and sludge during groundwater treatability studies at the site. Objectives of this HASCP include the following:

- The identification and evaluation of potential hazards.
- The definition of levels of protection required for certain work activities.
- The establishment and implementation of secure work zones.
- The evaluation and implementation of worker protective measures.
- The formulation of emergency action plans.
- The insurance of medical monitoring.
- Implementation of personnel training.
- The design and implementation of decontamination procedures.
- The enforcement of appropriate record keeping.

This Plan for the Remedial Design activities fulfills the requirements for a Contingency Plan specified in Appendix B of USEPA's Interim Final Guidance on

EPA Oversight of Remedial Designs and Remedial Actions Performed by Potentially Responsible Parties (OSWER Directive 9355.5-01 April 1990).

The ECKENFELDER INC. and contractor personnel covered by the Health and Safety Contingency Plan include those individuals working at the site who have potential for exposure to hazardous waste, hazardous substances, or a combination of these materials. This HASCP complies with the requirements of the Occupational Safety and Health Administration (OSHA) Standards as stated in 29 CFR 1910 with emphasis on subsection 1910.120 (Hazardous Waste Operations and Emergency Response), 1910.1000 (Air Contaminants) and 1910.1200 (Hazard Communication, Right-to-Know Law), 1904 (Recording and Reporting Occupational Injuries and Illnesses), 1990 (Identification, Classification and Regulation of Potential Occupational Carcinogens), applicable portions of Section 1926 (Safety and Health Regulations for Construction), and any other federal or state statutes or regulations that may be determined applicable. Amendments to this Plan will be made as the contaminant profile information is updated, a change in work status or task is made, or as regulatory requirements dictate. Any changes to the Plan will be brought to the attention of those covered under the Plan through additional training.

1.2 SITE BACKGROUND

Site background is included in the "In Situ Vapor Stripping Pilot Scale Treatability Study Work Plan, Lord/Shope's Landfill, Girard Township, Pennsylvania". As future data are generated, they will be reviewed and this Health and Safety Contingency Plan changed accordingly.

1.3 OBJECTIVES OF THE WORK PLAN

The field investigations to be conducted as part of the remedial design (RD) have been identified and discussed in detail in the RD Work Plan. The work for the purposes of the HASCP has been divided into 3 individual tasks each for Phases 1 and 2 as summarized on Table 1-1 and six tasks for Phase 3.

1.4 PERSONNEL REQUIREMENTS

To promote safe work practices, no activity will be conducted by an individual employee working alone. At least two persons will be present at the site during each of the field tasks identified on Table 1-1.

TABLE 1-1

LIST OF FIELD TASKS

PHASE 1

1. Extraction Well Installation

2. Vapor Extraction and Sampling - Landfill
   - Crested Soil
   - Toe of Landfill

3. Monitoring Probe Installation (or optional passive wells or vents)

PHASE 2

1. Recovery Well Installation

2. Monitoring Well Evaluation

3. Groundwater Sampling (optional)

PHASE 3

1. Groundwater Component Sampling

2. Groundwater Composite Sampling

3. Clarifier Effluent Sampling

4. Filter Effluent Sampling

5. Final Effluent Sampling

6. Sludge Sampling

1.5 VISITORS

Visitors to the Secure Zone will comply with medical training requirements as described in Sections 4.0 and 6.0 and Entry/Exit Procedures as described in Section 8.1 of this HASCP.

1.6 DEFINITIONS

As used in the HASCP, the following terms have been defined:

- "Active Operations" - Activities resulting in disturbance of soil, waste, groundwater, buildings, or equipment at a work area.
- "Authorized Personnel" - Any person, such as task-specific personnel, project personnel, oversight personnel, contractors, and consultants whose presence is authorized at the Project Site by Lord Corporation.
- "Contractor/Consultant" - Any person or firm, retained or hired by Lord Corporation, to carry out and/or supervise any portion of the activities conducted at the Project Site.
- "Exclusion Zone" - The area in which all personnel entering must be directly involved in the ongoing work, have designated personal protective equipment (PPE), and meet training and medical monitoring requirements. The exclusion zone will be defined and suitably marked.
- "MSDS" - Material Safety Data Sheets, which provide information on the physical, chemical, and hazardous properties of chemical compounds.
- "Oversight Personnel" - Any person, designated by the State, federal government, or Lord Corporation who is assigned to carry out oversight work.
- "PPM" - Parts per million; expressed as PPM(v) for gases and vapors.

- "Project Personnel" - Any person or contractor, assigned by Lord Corporation, its consultants, or its contractors to carry out work at the Project Site (e.g., Project Director, Project Manager, etc.).

- "Project Health and Safety Officer" - The designated person responsible for overall implementation of the Health and Safety Contingency Plan.

- "Project Site" - The area defined by a specific project Work Plan, as well as contiguous areas to which access is required for the execution of the field tasks which may be set forth in a Work Plan.

- "Site Safety Officer" - The person(s) designated by Lord Corporation, or the contractor/consultant, who is responsible for supervising the Health and Safety Contingency Plan.

- "Support Zone" - The area outside the exclusion zone that is considered clean for the purpose of the Health and Safety Contingency Plan. It is used for transfer of equipment and materials (i.e., support) into the secure area.

- "Task-Specific Site Personnel" - Any person or contractor assigned by Lord Corporation and/or its consultants/contractors to carry out work at the Project site.

- "Secure Zone" - The area within a radius of approximately 50 ft established from the center of the work area (e.g. drilling site) and indicated by a visible surface device or sign placed at the entrance of Shope's Landfill.

2.0 KEY PERSONNEL/IDENTIFICATION OF HEALTH AND SAFETY PERSONNEL

2.1 KEY PERSONNEL

The corporate Health and Safety Officer for this project will be Jane E. Lyons, CSP, of ECKENFELDER INC. In this capacity, Ms. Lyons will oversee compliance with applicable health and safety regulations. Under Ms. Lyons' direction, day-to-day site safety activities will be overseen by site safety officers. Safety is affected by the actions of all involved parties or organizations. For this reason, the following list of key personnel and their organizations have been identified.

RESPONSIBILITY	AFFILIATION	NAME	PHONE NUMBER
Project Manager	Lord Corporation	[redacted]	
Site Contact/ Coordinator	Lord Corporation		
Project Director	ECKENFELDER INC.		
Project H&S Officer	ECKENFELDER INC.		
PHASE 1			
Project Manager	ECKENFELDER INC.		
Site Safety Officer	ECKENFELDER INC.		
Alternate Site Safety Officer	ECKENFELDER INC.		
PHASE 2			
Project Manager	ECKENFELDER INC.		
Site Safety Officer	ECKENFELDER INC.		

PHASE 3

Project Manager	ECKENFELDER INC.	Stephen R. Tate	615-255-2288
Site Safety Officer	ECKENFELDER INC.	Mark P. Cashman	615-255-2288

- The Project Director is responsible for the overall direction and completion of the project.

- The Project Manager is responsible for the direction and coordination of the field investigation activities.

- The Project Health and Safety Officer's responsibilities are to ensure that the Health and Safety Contingency Plan is properly implemented, maintained, and to identify any hazards which are not discussed in the Plan.

- The Site Safety Officer is responsible for the dissemination of all information contained in the Plan to the workers on site, and in the absence of the Project Health and Safety Officer from the site, will fulfill the obligations of the Project Health and Safety Officer. This includes attendance at Site Safety meetings, conducting site training sessions, reporting all incidents which happen to personnel under his supervision, and the timely submission of required forms.

- The Alternate Site Safety Officer is responsible for fulfilling health and safety duties on site in the absence of the Site Safety Officer.

- The Site Contact is responsible for the education of site workers in all Shope's Landfill safety procedures and equipment not specifically discussed in this Plan.

3.0 TASK/OPERATION SAFETY AND HEALTH RISK ANALYSIS

3.1 IDENTIFICATION OF POTENTIAL HAZARDS

The potential routes of exposure to the chemical compounds found at the site include inhalation, skin absorption, and ingestion.

Compounds that may pose a potential hazard have been determined. Table 3-1 lists an inventory of these compounds and the Permissible Exposure Limits (PEL) established by the Occupational Safety and Health Administration (OSHA), and Threshold Limit Values (TLV) as published by the American Conference of Governmental Industrial Hygienists.

The potential routes of exposure for the chemicals listed in Table 3-1 include inhalation, skin absorption, and ingestion. Site personnel will be informed of these risks and appropriate monitoring and personal protective equipment (PPE) will be utilized. Material safety information for the compounds of interest (Addendum 1) will be maintained on site for ready reference by personnel and medical staff, should it be necessary.

Exposure limits for the compounds of interest (Table 3-1) were developed from OSHA 29 CFR 1910.1000 (Air Contaminants) and reflect the final rule values. The ionization potentials of compounds are noted on Table 3-1. This will serve as a guide to the HNU response to specific compounds.

3.2 TASK RISK ANALYSIS

A risk analysis for each field task identified by the HASP has been conducted. Table 3-2 provides a summary of tasks planned for the site with hazards and protective measures anticipated for each. However, should contaminants be encountered, there are only two probable routes of exposure: 1) the inhalation of hazardous vapors from the groundwater or soil, and 2) direct dermal contact with contaminants contained in the groundwater or soil. For

TABLE 3-1

COMPOUNDS OF INTEREST AND
OSHA PERMISSIBLE EXPOSURE LIMITS

Compounds	CAS No.[a]	PEL[b] TWA ppm(v)	PEL[b] TWA mg/m3[c]	STEL[d] TWA ppm(v)	STEL[d] TWA mg/m3[c]	TLV[e] ppm(v)	TLV[e] mg/m3[c]	eVg
INORGANIC								
Arsenic	7440-38-2	--	0.5	--	--	--	0.2	--
Barium	7440-39-3	--	0.5	--	--	--	0.5	--
Cadmium	7440-43-9	--	0.2	--	--	--	0.05	--
Chromium	Varies	--	0.5	--	--	--	0.5	--
Lead	7439-92-1	--	0.05	--	--	--	0.15	--
ORGANIC (10.2 HNU)								
Acetone	67-64-1	750	1,800	1,000	2,400	750	1,780	9.69
Benzene	71-43-2	1	--	50	--	0.1	0.3	9.25
2-Butanol	78-92-2	100	305	150	455	100	305	9.73
Cyclohexanone	108-94-1	25-skin	100	--	--	25-skin	100	9.14
1,1-Dichloroethylene	75-35-4	1	4	--	--	5	20	9.46
trans 1,2-Dichloro-ethylene	540-59-0	200	790	--	--	200	793	9.96
Ethyl Benzene	100-41-4	100	435	125	545	100	434	8.76
Isopropyl Alcohol	67-63-0	400	980	500	1,225	400	983	10.16
Methyl Ethyl Ketone	78-93-3	200	590	300	885	200	590	9.53
Methyl Isobutyl Ketone	108-10-1	50	205	75	300	50	205	9.3
4-methyl-2-pentanone	108-11-2	25-skin	100	40	166	25-skin	104	9.30
Tetrachloroethylene	127-18-4	25	170	--	--	50	339	9.32
Tetrahydrofuran	109-99-9	200	590	250	735	200	590	9.5
Toluene	108-88-3	100	375	150	560	100	377	8.8
Trichloroethylene	79-01-6	50	270	200	1,080	50	269	9.45
Vinyl Chloride	75-01-4	1	20	20	80	5	13	10.0
Xylene	1330-20-7	100	435	150	655	100	434	8.45
ORGANIC (11.7 HNU)								
Carbon Tetrachloride	56-23-5	2	12.6	--	--	5-skin	31	11.28
Chloroform	67-66-3	2	9.7	--	--	10	49	11.3
1,1-Dichloroethane	75-34-3	100	400	--	--	200	810	11.06
Methyl Chloride	74-87-3	50-skin	105	100	205	50	103	11.28
Methylene Chloride	75-09-2	500	10	--	--	50	174	11.3
1,1,1-Trichloroethane	71-55-6	350	1,900	450	2,450	350	1,910	11.2

[a]Chemical Abstracts Service Number.

[b]Permissable Exposure Limit; Time Weighted Average (8 hr day, 40 hr week); ppm unless otherwise indicated; concentrations expressed in air; ppm (v): part per million of substance in air by volume.

[c]mg/m^3: milligrams of substance per cubic meter of air.

[d]Short Term Exposure Limit; 15 minute duration of exposure not to be exceeded any time during the day.

[e]TLV: Threshold Limit Value as published by the American Conference of Governmental Industrial Hygienists (1990-1991).

[f](C): Ceiling Value - the concentration that should not be exceeded during any part of the working exposure.

[g]Electron Volts - ionization potential of compounds.

TABLE 3-2

HAZARD ANALYSIS FOR WORK TASKS

Activity/Task	Phase 1 Hazard	Prevention of Hazard	Contingency Action
Monitoring Probe Installation (or optional passive wells or vents)	Inhalation of or direct contact with contaminants; weather related exposure	Appropriate personal protective equipment; air monitoring; air monitoring	Decontamination; first aid
Extraction Well Installation	Inhalation of or direct contact with contaminants; weather related exposure; injury from drilling equipment	Appropriate personal protective equipment; air monitoring Trained operators; hard hats; caution in vicinity of equipment	Decontamination; first aid
Sampling: Ports, Probes, Wells	Inhalation of or direct contact with contaminated matrices; weather related exposure	Appropriate personal protective equipment; air monitoring	Decontamination; first aid
Management of Demister Condensate (possible)	Inhalation of or direct contact with contaminated matrices; weather related exposure	Appropriate personal protective equipment; air monitoring	Decontamination; first aid

Activity/Task	Phase 2 Hazard	Prevention of Hazard	Contingency Action
Monitoring Well Evaluation Groundwater Sampling	Inhalation of or direct contact with contaminants; weather related exposure; injury from drilling equipment	Appropriate personal protective equipment; air monitoring; Trained operators; hard hats; caution in vicinity of equipment	Decontamination; first aid
Recovery Well Installation	Inhalation of or direct contact with contaminants; weather related exposure; injury from drilling equipment	Appropriate personal protective equipment; air monitoring; air monitoring; trained operators; hard hats; caution in the vicinity of equipment	Decontamination; first aid

Activity/Task	Phase 3 Hazard	Prevention of Hazard	Contingency Action
Grab Sampling	Inhalation of or direct contact with contaminants; weather related exposure	Appropriate personal protective equipment; air monitoring	Decontamination; first aid

inhalation, prevention of exposure is accomplished by appropriate air monitoring within the breathing zone and the use of air-purifying respirators, if appropriate. For direct contact, prevention of exposure is accomplished by the proper selection and use of protective clothing.

Precautions will also be taken to avoid the following potential hazards:

- Electrical
- Mechanical
- Fire/Explosion
- Heat and Cold Stress
- Acoustical

These potential hazards are common to most work places. The Site Safety Officer will address these potential hazards during site inspections. All potential equipment hazards will be discussed during site safety meetings. Workers will be advised of all known potential hazards at the site prior to beginning work, and thereafter, as needed. They will be encouraged to be observant of site safety and health hazards and to report them to their supervisors and the Site Safety Officer.

Safety glasses with side shields, steel-toed boots, and hard hats will be required to be worn at all times. Fire extinguishers, respirators, and first aid kits will be available for use as needed in the immediate vicinity of the work area. All site workers will be trained in their use prior to arrival on site and advised of their availability and location.

All equipment will be operated by trained personnel as required. All employees will be cautioned during site safety meetings to be aware of moving equipment and to watch out for other workers as well.

3.3 INSPECTIONS AND EVALUATIONS BY THE SITE SAFETY OFFICER

At a minimum, on a daily basis during field operations, the Site Safety Officer shall visually inspect all site activities for compliance with this Health and Safety Contingency Plan. The results of this inspection will be recorded on the daily log developed specifically for the site (Figure 3-1). Deficiencies in compliance will be corrected upon discovery. The remedial action taken shall be noted on the daily log as well as when the remedial action is completed.

At a minimum, on a weekly basis during field operations, or upon a major change in planned activities, the Site Safety Officer shall evaluate the effectiveness of the PPE program for the site. This shall include summarizing site inspection notes regarding worker's use and decontamination of PPE, review of OVA/HNU air monitoring and calibration data, and a consideration of possible PPE program modifications, if any. This report shall be transmitted to the ECKENFELDER INC. Corporate Health and Safety Officer.

3.4 PERIMETER AIR MONITORING

Air monitoring will be conducted with either an OVA/HNU's (10.2 and 11.7 eV lamps) adjacent to Secure Zones where wells are being installed where other tasks are being performed. If the concentration within the Exclusion Zone exceeds 15 ppm above background on the OVA/HNU for 5 min, additional perimeter measurements will be taken downwind, and a higher level of PPE may be required, as shown in Table 5-1. Ionization potentials of compounds are specific on Table 3-1. Refer to this table to determine the response of the OVA/HNU 10.2 or 11.7 lamp.

3.5 DRILLING HAZARDS

Physical hazards that may generally be associated with power auger drilling operations include the following:

- Moving parts on auger that may catch clothing.
- Vibration from auger.

ECKENFELDER INC.

PERSONNEL PROTECTION DAILY LOG

Project: _____

Client: _____ Job No. _____

Location: _____ Instrument Readings & Specifications by: _____

Date: _____

Weather Conditions: _____ Hazards Noted:

_____ Chemical: _____

Personnel On Site: _____

_____ Non-chemical: _____

_____

Site Instrument Readings:

☐ HNU or ☐ OVA Level of Protection: _____

Calibration Date: _____ Dress of the Day: _____

	Reading	Time
Background:	_____	_____
Perimeter Areas:	_____	_____
Active Work Area:	_____	_____
	_____	_____

Changes During the Day: _____

Explosion Meter:

	Reading	Time
Perimeter Areas:	_____	_____
Active Work Area:	_____	_____

Decontamination Procedures: _____

Oxygen Meter:

	Reading	Time
Perimeter Areas:	_____	_____
Active Work Area:	_____	_____

Remedial Actions Taken _____

Date Remedial Action Complete : _____

Other Readings: _____ Site Safety Officer:

Name: _____

Work Planned: _____ Signature: _____

Title: _____

Work Area: _____

FIGURE 3-1

- Movement of auger should it hit stone.

- Possible fire hazard from gasoline powered auger.

Hazard Prevention

- Hard hats must be worn <u>at all time</u> when working in a Secure Zone. Loose clothing will be secured.

- No smoking in secure areas to reduce fire hazard.

3.6 PHYSICAL, HEALTH, FIRE AND EXPLOSION HAZARDS/FIRST AID

Fire is a remote possibility when air is introduced into a capped industrial landfill. If any of the monitored parameters (temperature, CO_2 content, opacity as monitored by the ISVS Mobile Unit) indicate an unacceptable increase in value, work will stop and the potential for an incipient fire investigated. All personnel except those involved in the investigation will leave the site.

A tanker truck of liquid nitrogen will be on call. Should a fire begin inside the landfill, the landfill will be flooded with nitrogen gas, thus breaking the fire triangle.

3.7 UNANTICIPATED HAZARDS

The following conditions, situations, etc. are not anticipated at this site and therefore safety procedures appropriate to them are not included in this Plan. If any of the items are encountered or discovered, the Site Safety Officer is to immediately contact the ECKENFELDER INC. Corporate Health and Safety officer to define a proper response. Work in this area must stop until a response is received.

- The need to handle, open, sample, or ship drums or containers of hazardous substances (other than the samples to be collected as identified in the Project Work Plan).

- The need to handle, enter, open, sample, or ship tanks or vaults containing hazardous substances.

3.8 GENERAL SAFETY PROCEDURES

The following general safety rules must be followed by all project personnel:

- All safety equipment and protective clothing will be worn at all times in Exclusion Zones and during decontamination, by all persons, in conformance with this plan and the requirements of 29 CFR 1910.120.

- Unnecessary contact with contaminated surfaces or with surfaces suspected of being contaminated should be avoided.

- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited in any restricted or affected area.

- Since medicines and alcohol can potentiate the effects of toxic chemicals in exposure situations, medicines and alcohol should not be used by employees working on site. Personnel who must be on medication should advise their supervisor and the Site Safety Officer prior to beginning work on site.

- Hands and face must be thoroughly washed upon leaving the work area and before eating, drinking, or other activities.

- Personnel should shower as soon as possible after the protective clothing is removed and the activity for the day has been terminated.

3.9 PROCEDURES FOR WEATHER-RELATED PROBLEMS

3.9.1 Heat Related

When coveralls made of Tyvek®/Saranex® are worn, body ventilation and evaporation are greatly reduced. Frequent breaks will be scheduled for personnel wearing the coveralls during periods of hot weather. Employees will be advised of the effects of heat stress, provided with adequate liquids while on site, and be instructed to observe each other for signs of heat stress during hot weather. Signs of heat stress are summarized as follows:

- Heat Exhaustion - Clammy skin, confusion, dizziness, fainting, fatigue, heat rash, light-headiness, nausea, profuse sweating, slurred speech, weak pulse.

- Heat Stroke - Confusion, convulsion, hot dry skin, high temperature (yet may feel chilled), incoherent speech, staggering gait, cessation of sweating, unconsciousness.

These signs can be distinguished from those associated with chemical hazards which are characterized by behavioral changes, breathing difficulties, change in complexion or skin color, coordination difficulties, coughing, dizziness, drooling, diarrhea, fatigue or weakness, and irritability. In addition, cold weather related stress factors must be considered. Frequent breaks to warm indoor environmentals will be arranged during especially cold periods.

3.9.2 Cold Related Illness

Cold weather related stress factors must be considered. Hypothermia is a general cooling of the body. The stages of hypothermia are as follows:

- Shivering (a response that generates heat).

- Apathy and decreased muscle function.

- Decreased level of consciousness with a glassy stare and possible freezing of the extremities.

- Decreased vital signs with slow pulse and slow respiration rate.

Hypothermia is an acute emergency requiring immediate medical attention. Keep the patient as warm and dry as possible until professional medical attention is available.

Prevention is important. Proper clothing is essential. Frequent breaks to indoor environments will be arranged during especially cold periods.

Work will be suspended during any weather conditions that are sufficiently extreme to potentially affect the adequacy of the HASCP or the integrity of equipment, such as heavy rains, heavy snow fall, electrical storms, or extreme heat or cold. The Site Safety Officer is responsible for determining when to suspend work.

3.10 INSECT HAZARDS

The prevention of Lyme Disease is important during spring, summer, and fall months. Lyme Disease is a bacterial infection transmitted by the bite of a deer tick. Many deer ticks found in the Northeast U.S. carry Lyme Disease bacteria.

To prevent the bite of a deer tick, avoid grassy areas when possible. Wear protective clothing (light colored). Use repellant containing "Permethrin" or "Deet". Make self inspection a habit following exposure to an area which may contain deer ticks.

- Symptoms: headache, flu-like symptoms, a spreading ring-like rash, swelling and pain of the joints.

- Tick Removal: Remove the attached tick immediately. Use tweezers to grabs the tick's head, near the skin, and slowly pull straight out. If possible, save the tick for laboratory analysis. If unsure of proper tick removal, consult a physician.

4.0 PERSONNEL TRAINING REQUIREMENTS

4.1 TRAINING

ECKENFELDER INC. personnel or their subcontractors working in a Secure Zone will have been trained pursuant to OSHA 29 CFR 1910.120(e). At a minimum, all workers will have documented forty (40) hrs of training. In addition, each individual so required, will have documented eight (8) hrs of annual refresher training and have been trained in the calibration and/or maintenance of field monitoring and sampling equipment. documentation of classroom training and alternative training experience must be made available if requested.

Lord Corporation personnel training requirements are based on Mr. George Kickel's letter of May 9, 1990 to Ms. Anka of OSHA and her response to Mr. Kickel dated May 29, 1990.

4.2 TRAINING AND BRIEFING TOPICS FOR SITE ACTIVITIES

Training Topics

- Site Characterization
- Hazards
- Medical Surveillance Requirements
- Symptoms of Overexposure to Hazards
- Site Control
- Training Requirements
- Overhead and Underground Utilities

The above topics, as appropriate to the site, will be discussed by the Site Health and Safety Officer during a work start-up briefing. All personnel who will be working in Secure Areas will attend the work start-up briefing. Personnel will complete and sign an acknowledgment form attesting to their review of the HASCP and attendance at the work start-up briefing (Figure 4-1). Additional training may occur on a daily basis relative to planned tasks and may also occur as events or circumstances arise that require revision to the HASCP.

NAME _____ DATE _____

EMPLOYER _____

ACKNOWLEDGMENT

TO BE SIGNED AND RETURNED TO

ECKENFELDER INC. HEALTH AND SAFETY OFFICER

I have received and carefully read the Site Safety and Health Contingency Plan for the Shope's Landfill site. I agree to abide by these safety rules, regulations, and guidelines while working at the Shope's Landfill site, and understand that any violation of these rules will result in my removal from the facility.

Signature _____

Print Name _____

I have completed and understand the training program, including the subjects listed below addressed during the course of site specific training.

- Work Rules and Safety Requirements
- Personal Protective Equipment (PPE)
- Potentially Hazardous Chemicals
- Emergency Equipment
- Reporting of Injuries and Illnesses
- Emergency Procedures
- Job Assignment
- Personal Hygiene
- Motor Vehicle Equipment
- Standard Operating Procedures

Signature _____

Print Name _____

I further affirm that at a minimum, a respirator qualitative fit test has been performed and a respirator of the same type has been assigned for my use.

Signature _____

Print Name _____

* *

I certify that this individual has received adequate training in all aspects of this Health and Safety Contingency Plan and is knowledgeable in the use and care of personal protective equipment.

SAFETY OFFICER

Signature _____ Date _____

Print Name _____

FIGURE 4-1

5.0 PERSONAL PROTECTIVE EQUIPMENT TO BE USED

5.1 PERSONAL PROTECTION

Use of personal protective equipment (PPE) is a major means to minimize potential exposure. The levels of protection for personnel have been based on Occupational Health Guidelines (OSHA) for the compounds of concern, the U.S. Environmental Protection Agency (EPA) Occupational Health and Safety Manual, and the Hazardous Substances Data Bank of the National Library of Medicine.

All personnel working in the Secure Zone will have their own personal safety equipment and protective clothing, which will be used according to the direction of the Site Safety and Health Officer. All non-disposable PPE will be kept clean and maintained. Personnel will be trained in the use, limitations and maintenance of PPE and will be properly fitted prior to beginning site activities.

It is unlikely that personnel will encounter conditions which are immediately dangerous to life and health (IDLH). Therefore, no special engineering controls or extraordinary work practices are deemed necessary.

5.2 LEVELS OF PERSONAL PROTECTION

The levels of personal protection expected to be used are summarized in Table 5-1. When the landfill cap is penetrated, Level B will be worn until airborne concentrations are established. Personnel working in the Secure Zone will continue to wear Level B PPE as long as the OVA/HNU reads >50 ppm and less than 1,000 and the individual Draeger tube measurements are positive. Due to the various compounds at the site and varying ionization potentials of the compounds, OVA/HNUs with 10.2 and 11.7 eV lamps will be used. (Refer to Table 3-1 for ionization potentials of compounds).

Level C protection can be implemented when the OVA/HNU reads >15 ppm and <50 ppm in the breathing zone for five minutes and/or Draeger tube measurements are positive.

TABLE 5-1

DESCRIPTION OF LEVELS OF PERSONNEL PROTECTIVE EQUIPMENT AND WORK ACTIVITIES

Level	Level Application
Level B	
• Saranex® coveralls with hood	OVA/HNU >50 ppm and <1,000 ppm
• Self-Contained Breathing Apparatus (SCBA)	
• Air monitoring with an OVA/HNU and combustible gas monitor	
• Chemical resistant gloves	
• Inner gloves	
• Hard hat	
• Boots and chemical resistant boot covers	
Level C[1]	
Modified Level D plus:	
• Tyvek®/Saranex® coveralls with hood	OVA/HNU >15 ppm but <50 ppm
• Full face respirators equipped with cartridges for organic gases and vapors[a] and/or particulates	Positive Drager tube > action level
• Air monitoring with an OVA/HNU and a combustible gas/oxygen indicator	
• Draeger colometric detector tubes	
Modified Level D[1]	
• Work uniform with long sleeves and long pants	OVA/HNU <15 ppm and Draeger tubes <action level for Benzene, Carbon Tetrachloride, Chloroform 1,1-Dichloroethylene 1,2-Dichloroethane, Vinyl Chloride
• Tyvek® coveralls[b]	
• Chemical resistant gloves	
• Inner gloves	
• Boots and chemical resistant boot covers	
• Safety glasses with side shields	
• Hard hat	
• Air monitoring with an OVA/HNU[a], and a combustible gas/oxygen indicator	

[a]Respirators also to be used when OVA/HNU readings rise above 15 ppm for 5 min or longer when using Modified Level D protective ensemble.
[b]Tyvek coveralls to be used during specified sampling or drilling operations.

1. Cotton gloves and undergarments are recommended to be worn to provide for perspiration absorption which serves as a cooling device for the body.

Modified Level D protection can be established when the OVA/HNU reads <15 ppm in the breathing zone and Draeger tube measurements are as follows:

- Benzene - <0.5 ppm
- Carbon Tetrachloride - <2 ppm
- Chloroform - <5 ppm
- 1,1-Dichloroethylene - <2 ppm
- 1,2-Dichloroethane - <5 ppm
- Vinyl Chloride - <0.5 ppm

The following conditions will require Level B protective equipment:

- An OVA/HNU sustained indication of 50 ppm or greater but less than 1,000 ppm of total volatile organics for one minute or more in the area of working personnel.

- A combustible gas meter indication of 10 percent of the lower flammable limit.

- An oxygen deficient atmosphere of 19.5 percent or less.

- An OVA/HNU sustained concentration exceeding the maximum allowable concentration specified on the respirator filter cartridge by the manufacturer.

Odor threshold values are listed in Table 5-2. These values will be referenced to insure that the odor threshold value is below the PEL standard as listed in Table 5-2. Should the odor threshold exceed the PEL and monitoring equipment show ambient air levels above background, all personnel will evacuate until Level B is donned and a laboratory analysis confirms the specific compounds and concentrations. A condition where the odor threshold of a compound exceeds the PEL will require a positive pressure self contained breathing apparatus, as the warning property required to wear an air purifying respirator has been exceeded. The point when an individual smells the compound may be above the PEL and therefore exposure would be occurring.

TABLE 5-2

ODOR THRESHOLD LIMIT VALUES FOR THE
COMPOUNDS OF INTEREST

Compounds	PEL TWA (ppmv)	Odor Threshold Limit (ppmv)	IDLH[a] (ppmv)	Odor Type	Respirator Cartridge Type[c]
Acetone	750	3.6-653	20,000	mint-like odor	OV, short service life
Arsenic	0.5 mg/m^3	ND	ND	ND	HE
Barium	0.5 mg/m^3	ND	250 mg/m^3	ND	DM
Benzene	1	34-119	2,000	aromatic	SA, OV
2-Butanol	100	0.12-11	8,000	strong odor	OV
Cadmium	.2 mg/m^3	ND	40 mg/m^3	ND	DM
Carbon Tetrachloride	2	140-584	300	ether-like odor	SA
Chloroform	2	133-276	1,000	pleasant, sweet odor	SA
Chromium	0.5 mg/m^3	ND	500 mg/m^3	ND	DM
Cyclohexanone	25	3.5	5,000	peppermint-like odor	OV
1,1-Dichloroethane	100	49-1,359	4,000	chloroform-like odor	SA, questionable warning properties
1,1-Dichloroethylene	1	190	--	chloroform-like odor	SA, poor warning
trans 1,2-Dichloro-ethylene	200	0.08-17	4,000	ether-like odor	OV, short service life
Ethyl Benzene	100	0.092-0.60	2,000		OV
Isopropyl alcohol	400	43	20,000	rubbing alcohol odor	OV
Lead	0.05 mg/m^3	--	ND	ND	DM
Methyl Chloride	50	>10	10,000	faint, sweet odor	SA, OV, warning unknown short service
Methylene Chloride	500	160	5,000	chloroform-like odor	SA, poor warning
Methyl Ethyl Ketone	200	2-85	3,000	ether-like odor	OV
Methyl Isobutyl Ketone	50	0.013	--	ether-like odor	OV
4-methyl-2-pentanone	25	0.01-1	2,000	ether-like odor	OV
Tetrachloroethylene	25	47	500	chloroform-like odor	SA,OV
Tetrahydrofuran	200	31	20,000	ether-like odor	OV
Toluene	100	0.16-37	2,000	aromatic odor	OV
1,1,1-trichorethane	350	390	1,000	chloroform-like odor	SA, OV

TABLE 5-2 (Cont'd)

ODOR THRESHOLD LIMIT VALUES FOR THE
COMPOUNDS OF INTEREST

Compounds	PEL TWA (ppmv)	Odor Threshold Limit (ppmv)	IDLH[a] (ppmv)	Odor Type	Respirator Cartridge Type[c]
Trichloroethylene	50	82	1,000	sweet, chloroform-like odor	SA, poor warning
Vinyl chloride	1	10-20	--	sweet odor	SA, OV
Xylene	100	20	10,000	aromatic odor	OV

ND = No Data.

[a]IDLH: Immediately Dangerous to Life and Health - A concentration value that is never exceeded while wearing an air purifying respiratory. Positive pressure self contained breathing apparatus required at this concentration or above.

[b]Respirator cartridge adequate to 10 times the PEL, 1,000 ppm, or specific concentration limit printed by the manufacturer on the respirator cartridge.

[c](F)HE: Full-face Respirator with High Efficiency cartridge.

[d]D/M: Dust/Mist cartridge.

[e]Concentration for full-face respirator with High Efficiency cartridge not to exceed 2.5 mg/m^3 (50 times the PEL). Positive pressure self contained breathing apparatus required above this concentration.

[f]DFM: Dust/Fume/Mist respirator cartridge.

[g]OV: Organic Vapor respirator cartridge.

[h]SA: Supplied Air respirator.

During all well construction activities, a combustible gas/oxygen monitor will be used to measure the percentage of the combustible gas/oxygen present in the breathing zone. An indication of combustible gas at 10 percent of the lower explosive limit, will cause work to cease immediately and all personnel will be evacuated to a safe area. Oxygen levels below 19.5 percent will require SCBA. Above 25 percent oxygen, all activities will be suspended because of fire hazard.

Specification sheets for all the monitoring equipment will be maintained within their shipping or storage containers. Included will be methods for calibration, operation, trouble-shooting, and minor repair. Availability of the specification sheets will be monitored by the Site Safety Officer. Any deficiencies or operating problems with monitoring equipment will be made known to the Project Health and Safety Officer. All continuous monitoring equipment will be serviced and batteries placed on charge, as they are required. A maintenance log will be maintained for monitoring equipment and any major discrepancy or operating malfunction must be brought to the attention of the Project Health and Safety Officer within 24 hrs.

5.3 REASSESSMENT OF PROTECTION PROGRAM

The Level of Protection provided by PPE selecting will be upgraded or downgraded based upon a change in site conditions or later findings.

When a significant change occurs, the hazards will be reassessed. Some indicators of the need for reassessment may include:

- The commencement of a new work phase not previously identified in this HASCP.
- Chemical compounds other than those previously identified in Chapter 3.0.
- A change in the work scope that affects the degree of contact with the chemical compounds.

5.4 WORK MISSION DURATION

Before personnel actually begin work in their PPE ensembles, the anticipated duration of the work mission will be established. The following factors are the most likely to limit the length of work periods in an Exclusion Zone.

- Ambient temperature and weather conditions as they may affect heat and cold stress.
- The capacity of personnel to work in full-face respirators, if necessary.
- The air supply consumption for SCBA.

5.5 CHEMICAL RESISTANCE AND INTEGRITY OF PROTECTIVE MATERIAL

The specific clothing materials have been specified on Tables 5-1 and 5-3 for the tasks to be performed under this HASCP. Information regarding the integrity and limitations of personnel protective equipment can be found in the publication Quick Selection Guide to Chemical Protective Clothing (1989). Should compounds be encountered on site that have not been identified by this HASCP or are not printed within the Guide, the Project Health and Safety Officer will be contacted.

5.6 INSPECTION OF PROTECTIVE EQUIPMENT

The proper inspection of PPE features several sequences of inspection depending upon the specific articles of PPE and frequency of use. The different levels of inspection are as follows:

- The inspection and operational testing of equipment received from the factory or distributor.

TABLE 5-3

CLOTHING MATERIALS CHEMICAL PROTECTION
BY GENERIC CLASS

Generic Class	Butyl Rubber	Poly Vinyl Chloride	Neoprene	Natural Rubber
Alcohols	E	E	E	E
Aldehydes	E-G	G-F	E-G	E-F
Amines	E-F	G-F	E-G	G-F
Esters	G-F	P	G	F-P
Ethers	G-F	G	E-G	G-F
Fuels	F-P	G-P	E-G	F-P
Halogenated Hydrocarbons	G-P	G-P	G-F	F-P
Hydrocarbons	F-P	F	G-F	F-P
Inorganic Acids	G-F	E	E-G	F-P
Inorganic Bases and Salts	E	E	E	E
Ketones	E	P	G-F	E-F
Natural Fats and Oils	G-F	G	E-G	G-F
Organic Acids	E	E	E	E

Legend: E - Excellent
G - Good
F - Fair
P - Poor

Source: Survey of Personnel Protective Clothing and Respiratory Apparata..., September 1974, DOT, USCG, Office of Research and Development.

TABLE 5-4

GLOVE MATERIALS - COMPARATIVE CHEMICAL RESISTANCE

KEY: E-excellent; G-good; F-fair; P-poor; NR-not recommended

Chemical	Neo-prene	Natural latex of rubber	Milled nitrille	Butyl
Acetaldehyde	E	G	G	E
Acetate	G	F	P	G
Acetic acid	E	E	E	E
Acetone	G	E	P	E
Acelylene gas	E	E	E	E
Acetylene tetrachloride	F	NR	F	F
Acrylonitrile	G	F	F	G
Amidol	G	E	F	E
Amine hardeners	F	F	G	G
Ammonium hydroxide	E	E	E	E
Amyl acetate	F	P	P	F
Amyl alcohol	E	E	E	E
Anhydrous ammonia	G	E	E	E
Aniline	G	F	P	F
Aniline hydrochloride	F	G	P	F
Aniline oil	F	G	P	F
Animal fats	E	P	E	G
Animal oils	E	F	E	G
Anodex	G	E	-	E
Anthracene	F	P	F	P
Aromatic fuels	P	NR	F	NR
Arsine	E	E	E	E
Asbestos	E	E	E	E
Asphalt	G	F	E	F
Banana oil	F	P	P	F
Benzaldehyde	F	F	G	G
Benzene	P	NR	F	NR
Benzol	P	NR	F	NR
Benzyl alcohol	E	E	E	E
Benzyl benzoate	G	F	G	F
Benzyl chloride	F	P	F	G
Biacosolve	G	P	G	P
Boron tribromide	G	P	P	P
Bromine	G	P	P	P
Bromoform	G	P	P	P
Butane	E	F	E	F
2-Butanone	G	G	F	G
Butyl acetate	G	F	P	F
Butyl alcohol	E	E	E	E
Butylaldehyde	G	G	E	G
Butylene	E	G	E	G
Cadmium oxide fume	E	E	E	E
Calcium hydroxide	E	E	E	E
Carbolic acid	E	E	F	E
Carbon dioxide	E	E	E	E
Carbon disulfide	F	F	F	F
Carbon tetrachloride	F	P	G	P
Castor oil	F	P	E	F
Cellosolve	F	G	G	G
Cellosolve acetate	G	F	G	G
Chlordane	G	F	G	F
Chlorine	G	F	F	G
Chlorine gas	G	F	F	G
Chlorobenzene	F	P	P	F
Chloroacetone	F	F	P	E
Chlorobromomethane	F	P	F	P
Chloroform	G	P	E	P
Chloronaphthalene	F	P	F	F
Chlorophenylene diamine	G	P	F	F
Chloropicrin	P	P	P	F
Chlorothene	P	NR	F	NR
Chromic acid	F	P	F	F
Chromotex	G	G	G	G
Citric acid	E	E	E	E
Coal tar pitch volatiles	F	P	F	-
Cottonseed oil	G	G	E	F
Cotton dust (raw)	E	E	E	E
Creosote	G	G	F	G
Cresol	G	G	F	G
Cupric nitrate	G	G	E	E

Chemical	Neo-prene	Natural latex of rubber	Milled nitrille	Butyl
Cyanide	G	G	G	G
Cyclohexane	G	F	G	F
Cyclohexanol	G	F	E	G
Cyclohexanone	G	E	F	G
Decaborane	F	P	F	F
Degreasing fluids	F	P	G	P
Diacetone alcohol	E	E	E	E
Diborane	F	P	F	F
Dibenzyl ether	G	G	F	G
Dibutyle phthalate	G	P	G	G
Dichloroethane	P	NR	F	NR
Dichloropropene	P	P	F	F
Diesel fuel	G	P	E	P
Diethanolamine	E	G	E	E
Diethylamine	E	G	E	G
Diethyltriamine	G	F	E	G
Diisobutyl ketone	P	F	P	G
Diisocyanate	G	P	G	E
Dimethylformamide	F	F	G	G
Dioctyl phthalate	G	P	E	F
Dioxane	E	G	G	G
Emulsifying agent	G	F	E	E
Emulthogene	G	F	G	E
Epichlorohydrin	G	P	F	G
Epoxy resins, dry	E	E	E	E
Esters	F	P	P	F
Ethane gas	E	G	E	E
Ethanol	E	E	E	E
Ethers	E	G	G	G
Ethyl acetate	G	F	F	G
Ethyl alcohol	E	E	E	E
Ethyl bromide	-	-	P	-
Ethyl ether	E	G	G	E
Ethyl butyl ketone	-	-	P	-
Ethyl formate	G	F	G	G
Ethylaniline	F	F	P	G
Ethylenediamine	E	G	E	G
Ethylene dichloride	F	P	P	F
Ethylene gas	E	G	E	E
Ethylene glycol	E	E	E	E
Ethylene oxide	G	F	G	-
Ethylene trichloride	F	P	G	P
Fatty acids	E	P	E	F
Ferrocyanide	F	G	G	E
Fluoric acid	E	G	E	E
Fluorine	G	F	F	G
Flourine gas	G	F	F	G
Formaldehyde	E	E	E	E
Formic acid	E	E	E	E
Freon 11	G	P	G	F
Freon 12	G	P	G	F
Freon 21	G	P	G	F
Freon 22	G	P	G	F
Furfural	G	G	G	G
Gasoline, leaded	G	P	E	F
Gasoline, unleaded	G	P	E	F
Glycerine	E	E	E	E
Glycerol	E	E	E	E
Glycol	E	E	E	E
Gold fluoride	G	E	E	E
Grain alcohol	E	E	E	E
Halogens	G	F	F	G
Hexamethylenetetramine	F	G	F	G
Hexane	F	P	G	P
Hexyl acetate	F	P	P	F
Hydraulic oil	-	-	-	-
ester base	E	P	F	G
petroleum base	G	P	E	P
Hydrazine	F	G	G	G
Hydrochloric acid	E	G	G	G
Hydrofluoric acid	E	G	G	G

Chemical	Neo-prene	Natural latex of rubber	Milled nitrile	Butyl
Hydrogen gas	E	E	E	E
Hydrogen peroxide-30%	G	G	G	G
Hydrofluosilicic acid	F	G	G	G
Hydroquinone	G	G	F	G
Inorganic salts	E	E	E	E
Iodine	G	F	G	G
Isooctane	F	P	E	P
Isopropanol	E	E	E	E
Isopropyl alcohol	E	E	E	E
Kerosene	E	F	E	F
Ketones	G	E	P	E
Lacquer thinner	G	F	P	F
Lactic acid	E	E	E	E
Lauric acid	E	F	E	E
Lineoleic acid	E	P	E	F
Linseed oil	E	P	E	F
Maleic acid	E	E	E	E
Mercuric chloride	G	E	G	E
Mercury	G	G	G	E
Methane gas	E	E	E	E
Methanol	E	E	E	E
Methyl acetate	G	F	P	G
Methyl alcohol	E	E	E	E
Methylamine	F	F	G	G
Methyl bromide	G	F	F	G
Methyl cellosolve	G	G	G	G
Methyl chloride	NR	NR	NR	NR
Methyl ethyl ketone	G	G	NR	E
Methyl formate	G	F	F	G
Methylene bromide	G	G	F	G
Methylene chloride	G	F	F	G
Methyl isobutyl ketone	F	F	P	E
Methyl methacrylate	G	G	F	E
Mineral oils	E	F	E	F
Monochlorobenzene	F	P	P	F
Monoethanolamine	E	G	E	E
Morpholine	E	E	G	E
Muriatic acid	E	G	G	E
Naphtalene	G	F	G	F
Naphthas, aliphatic	E	F	E	F
Naphthas, aromatic	G	P	G	P
Nitric acid	G	F	F	F
Nitric acid, red and white fuming	P	P	P	P
Nitrobenzene	F	P	F	F
Nitroethane	F	P	F	F
Nitrogen gas	E	E	E	E
Nitromethane	F	P	F	F
Nitropropane	F	P	F	F
Nitrous oxide	G	G	G	G
Octyl alcohol	E	E	E	E
Oleic acid	E	F	E	G
Oxalic acid	E	E	E	E
Oxygen, liquid	F	P	NR	F
Ozone	G	P	P	G
Paint thinners	G	F	G	F
Paint and varnish removers	G	F	F	F
Palmitic acid	E	E	E	E
Paradichlorobenzene	E	F	E	E
Parathion	P	F	F	F
Pentaborane	F	P	F	F
Pentachlorophenol	F	G	G	G
Pentane	E	G	E	G
Perchloric acid	E	F	G	G
Perchloroethylene	F	NR	G	NR
Perklene	E	NR	G	NR
Permachlor	E	F	E	NR
Petroleum distillates (naphtha)	G	P	E	-
Petroleum spirits	E	F	E	F
Phenol	E	F	F	G
Phenylenediamine	G	P	G	G

Chemical	Neo-prene	Natural latex of rubber	Milled nitrile	Butyl
Phenythydrazine	G	G	G	G
Phil. solv	E	F	E	G
Phosphoric acid	E	G	E	E
Pickling solution	G	G	G	E
Picric acid	E	G	E	G
Pine oil	E	P	E	F
Pitch	E	P	E	E
Plating solutions	E	E	E	E
Potassium alum	G	G	G	E
Potassium bromide	G	G	G	E
Potassium chrome alum	G	G	G	E
Potassium dichromate	F	F	F	E
Potassium terrocyanide	G	G	G	E
Potassium hydroxide	E	E	E	E
Printing inks	E	G	G	G
Propane gas	E	E	E	E
Propanol (iso)	E	E	E	E
Propyl acetate	G	F	F	G
Propyl alcohol	E	E	E	E
Propyl alcohol (iso)	E	E	E	E
Propylene gas	E	F	E	E
Propyne gas	E	F	E	E
Pyrethrum	E	E	E	E
Red fuming nitric acid	P	P	P	P
Rhodium fume and dust	E	E	E	E
Silver nitrate	E	G	E	E
Skydrol 500	P	G	P	G
Sodium carbonate metal	G	G	G	E
Sodium hydroxide	E	E	E	E
Sodium sulfite	G	G	E	E
Sodium thiosulfide	G	G	E	E
Solvarsol	E	F	E	F
Solvessos	P	P	G	P
Stearic acid	E	E	E	E
Stoddard solvent	E	F	E	G
Styrene	P	P	F	P
Styrene 100%	P	P	F	P
Sulfuric acid	G	G	G	G
Tannic acid	E	E	E	E
Tetrahydroborane	F	P	F	F
Tetraethyl lead	E	F	E	G
Tetrahydrofuran	P	F	F	F
Toluene	F	P	F	NR
Toluene diisocyanate	F	G	F	G
Toluol	F	P	F	NR
Trichlor	F	P	G	P
Trichloroethylene	F	F	G	P
Trichloroethane	P	P	F	P
Tricresyl phosphate	G	F	E	F
Tridecyl alcohol	G	F	E	F
Triethanolamine	E	G	E	G
Trinitrotoluene	G	P	G	F
Trinitralolual	G	P	G	F
Tripiane	E	P	E	F
Tung oil	E	P	E	F
Turca No. 2998	P	P	-	F
Turpentine	G	F	E	F
Unsymmetrical Dimethylhydrazine	F	P	F	P
Varnoline gas	E	F	E	F
Vanadium fume and dust	E	E	E	E
Varsol	G	F	G	F
Vegetable oils	E	G	E	G
Wood alcohol	E	E	E	E
Wood preservatives	G	F	G	G
Woodyouth	F	P	F	G
Xylene	P	P	F	P
Xylol	P	P	F	P
Xylidene	E	F	F	F
Zinc chloride	E	E	E	E

TABLE 5-4 (Cont'd)

- The inspection of equipment as it is issued to workers.
- The inspection after use or training and prior maintenance.
- The periodic inspection of stored equipment.
- The periodic inspection when a question arises concerning the appropriateness of the selected equipment, or when problems with similar equipment arises.

The primary inspection of PPE for activities will occur prior to immediate use and will be performed by the user. This will insure that the specific device or article has been checked out by the user, and that the user is familiar with its use. Table 5-5 is a PPE Inspection Checklist that should be referenced before, during, and after use of personal protective equipment.

TABLE 5-5

SAMPLE PPE INSPECTION CHECKLISTS

CLOTHING

Before Use:

- Determine that the clothing material is correct for the specified task at hand.
- Visually inspect for:
  - imperfect seams
  - non-uniform coatings
  - tears
  - malfunctioning closures
- Hold up to the light and check for pinholes.
- Flex product:
  - observe cracks
  - observe for other signs of shelf deterioration
- If the product has been used previously, inspect inside and out for signs of chemical attack:
  - discoloration
  - swelling
  - stiffness

During the work task, periodically inspect for:

- Evidence of chemical attack such as discoloration, swelling, stiffening, and softening. Keep in mind however, that chemical permeation can occur without any visible effects.
- Closure failure
- Tears
- Punctures
- Seam discontinuities

GLOVES

Before Use:

- Visually inspect for:
  - imperfect seams
  - tears, abrasions
  - non-uniform coating
  - pressurize glove with air; listen for pin-hole leaks

BOOT AND BOOT COVERS

Before Use:

- Visually inspect for:
  - imperfect seams
  - tears
  - missing or ripped elastic band
  - insects, snakes, spiders or etc. that may have crawled inside of boots

6.0 MEDICAL SURVEILLANCE REQUIREMENTS

6.1 MEDICAL MONITORING

Medical monitoring will be performed for all personnel working in a Secure Zone. Fitness to use respiratory protection will have been conducted within the last year. The medical monitoring physical will serve as either the baseline for new employees or as the annual physical for existing employees. The examination will have been conducted by a licensed physician who will maintain permanent records of all examinations and tests. Medical monitoring should meet or exceed regulatory compliance issues pursuant to OSHA 29 CFR 1910.94, .120, .134 and .0110 through .1045.

Included within these regulatory issues are the determination by a physician that an individual being examined is physically able to use an air purifying respirator and is able to perform the work defined within the specific job description. The capability of an individual to perform the specified work will be determined from examinations that will include:

- Complete medical and work histories
- Physical examination
- Pulmonary function test (FVC and FEV1)
- Chest x-ray every two years or earlier if required
- ECG (Electrocardiogram)
- Eye examination and visual acuity
- Audiometry
- Urinalysis
- blood chemistry (hematology, serum analyses, heavy metals toxicology)

6.2 PERIODIC MONITORING

All personnel are required to have obtained a medical physical within the last 12 months of going on site. This period may be shortened if the physician or

the Health and Safety Officer believe a shorter interval is appropriate. The physician performing the physical will insure the physical fulfills the requirements of 29 CFR 1910.120(f). Documentation attesting to current medical monitoring compliance may be maintained on site by the Site Safety Officer.

6.3 EXPOSURE/INJURY/MEDICAL SUPPORT

All personnel covered by this HASCP must report and are encouraged to seek medical attention and physical testing following an injury or possible exposure above established exposure levels.

7.0 FREQUENCY AND TYPES OF PERSONAL AIR MONITORING/SAMPLING

The purpose of air monitoring is to identify and quantify airborne contaminants in order to verify and determine the level of personal protection required. Initial screening for identification is generally qualitative. Subsequent testing is typically required to quantify concentrations. Continuous air monitoring will be used in secure areas to identify airborne contaminants using direct reading instruments: e.g., OVA/HNU and combustible gas/oxygen monitor and specific Draeger colormetric tubes (refer to Section 5.0 for details).

8.0 SITE CONTROL MEASURES

8.1 SECURE ZONE

Access into Secure Zones will be established by a visible surface device and/or sign at entry area. The Site Safety Officer will insure the integrity of the secured areas throughout the work day. Site activities requiring personnel access to a Secure Zone will be coordinated between Shope's Landfill, Lord Corporation , and the ECKENFELDER INC. Site Safety Officer. All personnel entering the work zone are required to have read this Health and Safety Contingency Plan, to sign the entry/exit log (Figure 8-1), and to adhere to the Contingency Plan requirements while in the vicinity.

Visitors must have their own National Institute of Occupational Safety and Health (NIOSH) approved safety equipment or they will be denied entry to the work site.

8.2 SITE COMMUNICATION PLAN

Successful communications between field teams and contact with personnel in the Support Zone is essential. The following communication systems will be available within Secure Zones:

- Normal communication
- Hand signals as follows:

Signal	Definition
Hands clutching throat	Out of air/cannot breath
Hands on top of head	Need assistance
Thumbs up	OK/I am alright/I understand
Thumbs down	No/Negative
Arms waving upright	Send backup support
Grip partners wrist	Exit area immediately

VISITOR SIGN IN SHEET

Date	Name	Representing	Time In	Time Out	Safety Plan Read (Yes √)	Building Location Visited	Protective Clothing (Yes √)	Remarks

FIGURE 8-1

8.3 MEDICAL ASSISTANCE/EMERGENCY CONTACTS

In the event of personnel exposure, accident, injury, or fire at the Shope's Landfill, the following general accident and emergency response procedures are to be followed by all personnel working under this Health and Safety Contingency Plan.

Should an emergency requiring evacuation (subsequent to a decision by the Site Safety Officer) occur, ECKENFELDER INC. and contractor personnel will evacuate the area to a location established by the ECKENFELDER INC. Site Safety Officer. These locations will be located upwind of the predominant wind flow and be designated on a daily basis to reflect the daily wind direction. All designated locations will be a safe distance from the area in which the emergency occurred and be explained during the initial site safety briefing. Following the evacuation, the Site Safety Officer will initiate a head count to insure all personnel who entered the site have successfully been evacuated. Any discrepancies will be brought to the immediate attention of the Site Coordinator and/or the responding emergency service(s).

The supervisor on scene should call emergency services and, as soon possible notify his/her immediate supervisor, the Site Safety Officer, or call and explain that an emergency incident has or is occurring. Individuals so notified should, as the circumstances indicate, contact as appropriate the following to obtain emergency assistance: the nearest telephone is located in the residence of Merryl Shope, which is immediately adjacent to the site.

	Phone
Girard Borough Police Department	(814) 777-2651
State Police	(814) 777-9611
Fire Department	911
HAMOT Medical Center, Erie, PA	(814) 870-6000
City County Emergency Management Agency	(814) 870-1950
Regional Poison Center	(814) 452-3232
HAMOT Poison Center	(814) 870-6111

8.4 MEDICAL EMERGENCY RESPONSE

The nearest medical facility is the HAMOT Medical Center in Erie, Pennsylvania. To travel to the HAMOT Medical Center take Peiper Road to Route 20. Turn right onto Route 20, and continue on Route 20 to State Street. Turn left on State Street. Continue to Hospital (201 State Street).

8.5 REQUIRED EMERGENCY CONTACTS

The following persons, departments, or organizations designated by "*" must be contacted when an emergency occurs. Other individuals based upon nature of the emergency listed should be notified as soon as possible. The Site Safety Officer shall, as time permits, insure these contacts are made and report to the ECKENFELDER INC. Project Manager of this activity.

	Phone	
	Office	Home
• Lord Corporation		
E.A. Miller*, Project Manager and Site Contact/Coordinator	814-868-0924	814-838-8763
George Kickel, Alternate Site Contact	814-868-0924	814-454-3665
• ECKENFELDER INC.		

[redacted]

9.0 DECONTAMINATION PLAN

9.1 STANDARD OPERATING PROCEDURES

Decontamination (DECON) is the physical process of removal of contaminants or potential contaminants from personnel and equipment. Personal decontamination for this HASCP will primarily consist of periodic disposal of outer protective clothing in containers established within Secure Areas designated by the Site Health and Safety Officer. Those items for disposal will be collected in a plastic-lined container and disposed of in a proper manner established by the Shope's Landfill contact. DECON stations will be established within each Contamination Reduction Zone.

9.2 LEVELS OF DECONTAMINATION REQUIRED FOR PERSONNEL

Personnel working in an Secure Zone will be required to wear modified Level B, C, or Modified D depending on air level concentrations. A Decontamination Area will be established in each Secure Zone as typically shown in Figure 9-1.

The procedure for Modified Level D decontamination will be:

- Step 1 - Removal of outer boots.
- Step 2 - Removal of outer gloves.
- Step 3 - Removal of Tyvek® clothing.
- Step 4 - Removal of inner gloves.

The decontamination procedures for Level C and Level B are shown in Figures 9-2, 9-3, and 9-4. In an emergency, the primary concern is to prevent the loss of life or severe injury to site personnel. Should immediate medical attention be required to save a life, decontamination should be delayed until the victim is stabilized. However, if decontamination can be performed without interfering with first aid or life saving techniques, or should a

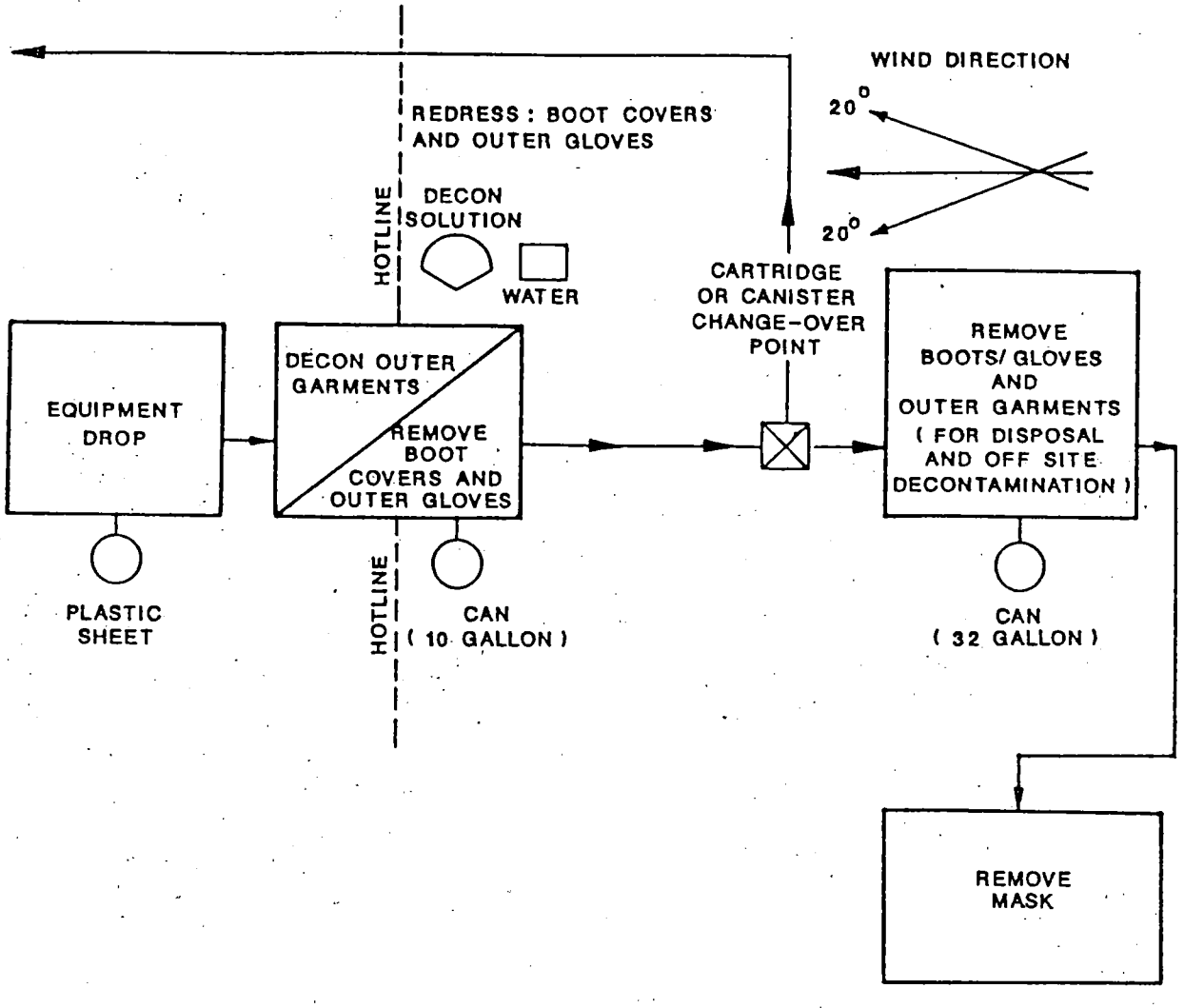


FIGURE 9-1

MINIMUM DECONTAMINATION LAYOUT
LEVEL C PROTECTION

ECKENFELDER INC. Nashville, Tennessee Mahwah, New Jersey

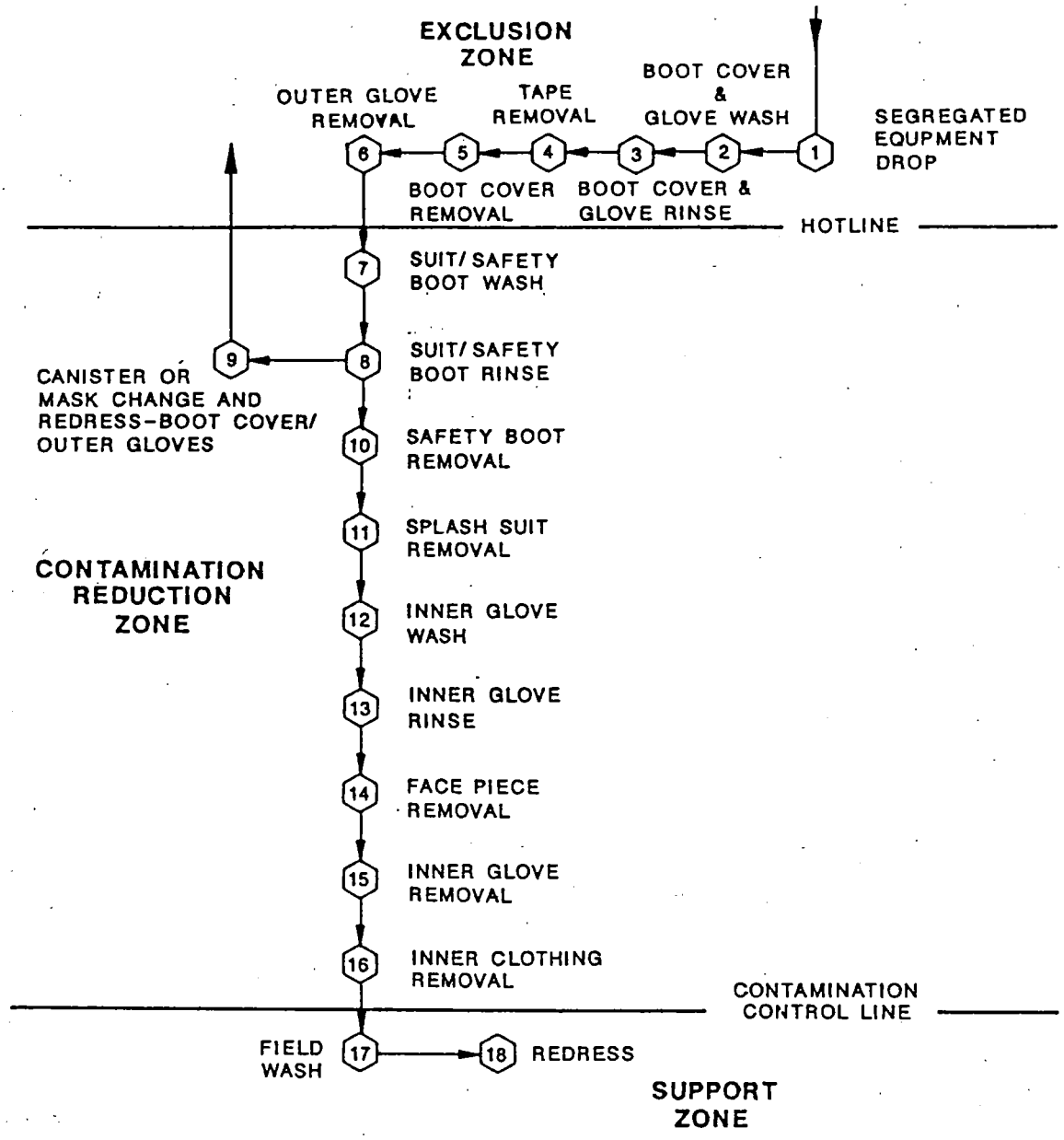


FIGURE 9-2

MAXIMUM DECONTAMINATION LAYOUT
LEVEL C PROTECTION

ECKENFELDER INC. Nashville, Tennessee
Mahwah, New Jersey

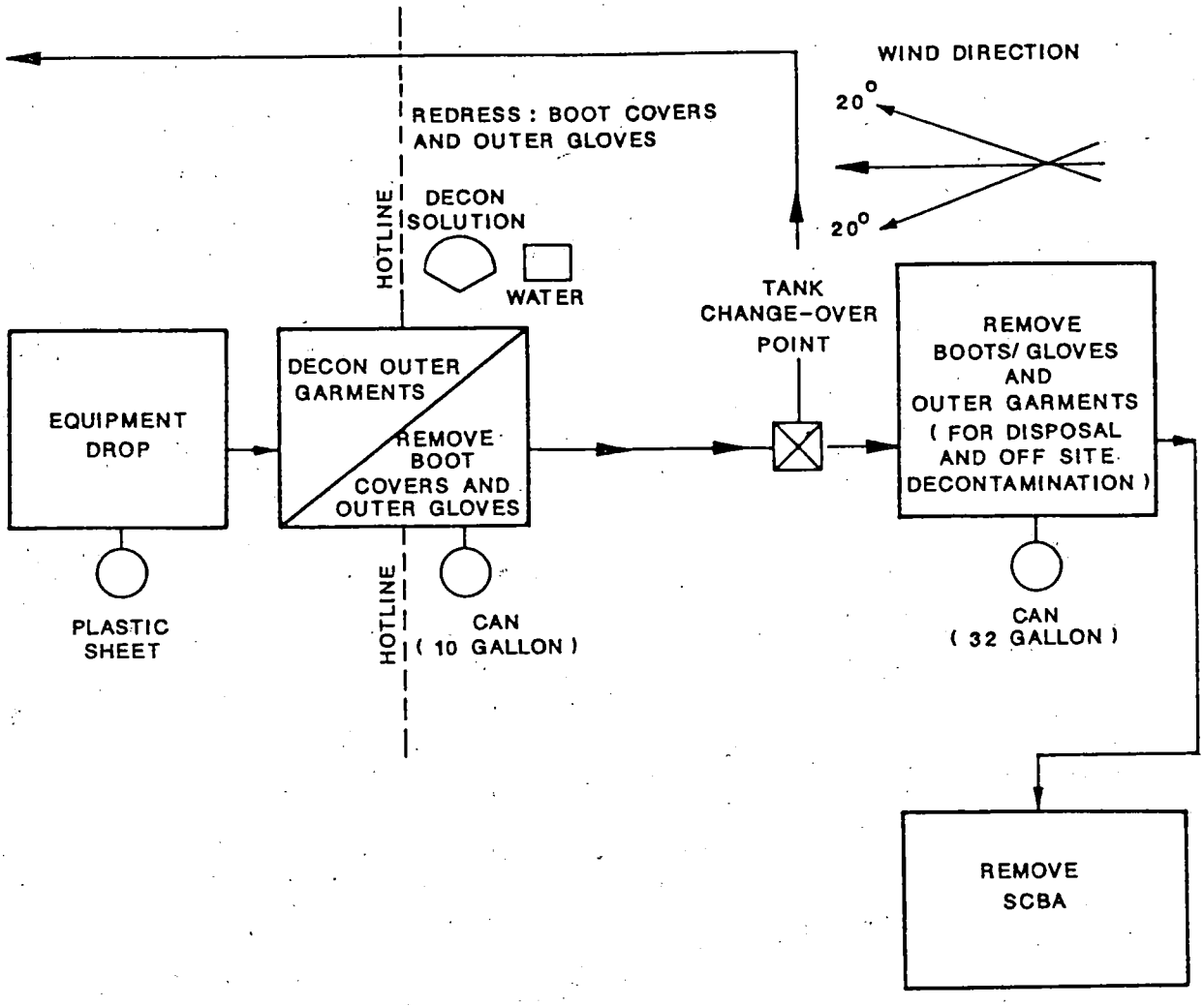


FIGURE 9-3

MINIMUM DECONTAMINATION LAYOUT
LEVELS A & B PROTECTION

ECKENFELDER INC. Nashville, Tennessee Mahwah, New Jersey

worker be contaminated with a extremely toxic or corrosive material that has the potential to cause severe injury or loss of life, decontamination must be performed immediately. If an emergency due to heat-related illness develops, protective clothing should be removed from the individual to reduce heat stress. During an emergency, provision should also be made for protecting medical personnel and disposing of contaminated clothing and equipment. Additional decontamination information is contained in Addendum 2.

10.0 EMERGENCY/DISASTER CONTINGENCY PLAN

10.1 PRE-EMERGENCY PLANNING

Sections 4, 5, 6, and 7 of the Emergency/Disaster Contingency Plan will be reviewed with project personnel along with the HASP before the project start-up. Table 10-1 identifies the potentially hazardous conditions that may be associated with the specific task activities of each Phase. The Emergency/Disaster Contingency Plan will be reviewed and revised as necessary by the Site Safety Officer. Prior to the start of any work tasks, the local fire department and HAMOT Medical Center will be contacted in writing by the Project Health and Safety Officer informing them of the scope and hazards of the work tasks.

10.2 PERSONNEL ROLES AND LINES OF AUTHORITY

The Site Safety Officer has the primary responsibility for coordinating response to emergencies on the project site. It is the responsibility of anyone observing an emergency situation to notify the Site Safety Officer. In case the Site Safety Officer cannot be reached immediately, the person observing the emergency can contact any of the following emergency services, as necessary:

	Phone
Girard Borough Police Department	(814) 777-2651
State Police	(814) 777-9611
Fire Department	911
HAMOT Medical Center, Erie, PA	(814) 870-6000
City County Emergency Management Agency	(814) 870-1950
Regional Poison Center	(814) 452-3232
HAMOT Poison Center	(814) 870-6111

10.3 EMERGENCY RECOGNITION AND PREVENTION

Table 10-1 and Sections 3.5, 3.6 and 3.7 provide a listing of chemical and physical hazards that may be encountered. Additional hazard as a direct result of site activities are listed in Table 10-1 with prevention and control

TABLE 10-1

EMERGENCY RECOGNITION/CONTROL MEASURES

Hazard	Specific Condition: Location	Prevention: Control
Fire/Explosion	Gasoline fueled equipment landfill	Nitrogen Gas System Fire inspections Fire extinguishers Water spray; foam
Vapor Air Release	Open well; seal opening with on site material	Alarm system; evacuation routes
Spill	Drill cuttings; DECON solvents and contaminated water/residues DECON station; staging area	Berms; dikes; sorbent materials; foams

techniques/mechanisms. Personnel working in Secure Zones will be familiar with the techniques of hazard recognition from pre-assignment training and from site-specific briefings. The Site Safety Officer is responsible for insuring that preventive devices and equipment are available to Secure Zone personnel.

10.4 EVACUATION ROUTES AND PROCEDURES

Should an emergency requiring evacuation occur, all personnel will evacuate the area to a location pre-established by the Site Safety Officer. These locations will be located, marked and will be 250 ft upwind of the Secure Area. Following the evacuation, the Site Safety Officer will initiate a head count to insure all personnel who entered the Secure Zone have successfully been evacuated.

In the event of an emergency which necessitates an evacuation of the Secure Zone, the following alarm procedure will be implemented:

- Three loud blasts on the vehicle or other horn - personnel will be expected to proceed to the designated evacuation area and will remain in the area until a re-entry to the Secure Zone is authorized.

10.5 INCIDENT REPORTING

Following an accident or incident, an incident report will be completed by a responsible individual at the scene. Information in the incident report will include, at a minimum, the following items:

- Name(s) of individuals involved or witnesses
- Date and time
- Exact location
- Description of incident
- Type of exposure suspected or nature of injury
- Nature of emergency response actions
- Corrective measures taken to prevent repeat of the incident

All incident reports will be filed with the Shope's Landfill Project Manager and ECKENFELDER INC Corporate Health and Safety Officer.

Further, in the event of a hazardous material spill or chemical release above the reportable quantity, the appropriate Federal and State agencies will be notified. Notification will be made through the Shope's Landfill Project Manager.

10.6 EMERGENCY MEDICAL TREATMENT PROCEDURES

Any individual who becomes ill or is injured while working within the exclusion zone must be decontaminated to the maximum extent possible. Should the injury or illness be minor in nature, full DECON will be administered prior to transport to a medical facility. If the individual's conditions is serious, a partial DECON should be completed (i.e., complete clothing removal and redressing in clean overalls or wrap the individual in a blanket). First aid should be administered while awaiting an ambulance or paramedic. All injuries and illnesses will be reported immediately as described in Section 10.2. Any vehicle used to transport contaminated or potentially contaminated personnel will be decontaminated as necessary.

10.7 FIRE OR EXPLOSION

In the event of a fire or explosion, the fire department, the Site Safety Officer and Project Contact should be notified immediately.

10.8 SPILL AND LEAKS

Personnel will report any spills or leaks to the Site Safety Officer and the Shope's Landfill Site Contact. Should a spill or leak occur which is a threat to human health or a release to environment (air, water or soil), the person observing the spill will:

- Evacuate or request an evacuation of any persons at risk.

- Inform Shope's Landfill Site Contact supervisor and/or Site Safety Officer immediately.

- Locate the source of the spillage and stop the flow if it can be done safely.

- Begin containment and recovery of the spilled materials utilizing appropriate response methodology and PPE, only if safe to do so.

10.9 EMERGENCY EQUIPMENT AND FACILITIES

The following equipment will be available at a Secure Zone:

- First aid kit
- Fire extinguishers
- Nitrogen Gas System
- Portable eye wash

11.0 CONFINED SPACE ENTRY PROCEDURES

A confined space provides the potential for unusually high concentrations of potential contaminants, explosive atmospheres, limited visibility and restricted movement. This section will establish requirements for safe entry, work and exit from confined spaces. Additional information regarding confined space entry can be found in 29 CFR 1926.21, 1910 and National Institute of Occupational Safety and Health (NIOSH) publication 80-106.

A confined space is defined as a space or work area not designed or intended for normal human occupancy, having limited means of egress and poor natural ventilation. A confined space may also include a structure (buildings or rooms) which has a limited means of egress. A permit is required to enter a confined space. Confined space entries are <u>not authorized</u> nor anticipated under this HASCP. All work tasks to which this HASCP applies will occur outside any area that may be considered to be a confined space.

12.0 IN SITU VAPOR STRIPPING MOBILE UNIT

The in situ vapor stripping (ISVS) mobile unit will be used on site to conduct a series of treatability studies. The unit is transportable and contained in a 8 ft by 12 ft trailer. The unit is placed on blocks and "tied down" once in place on site to secure against movement. Steps are required leading up to the ISVS unit door and should be in good condition to prevent falls when entering or exiting the unit.

In line in the soil gas air stream in the ISVS mobile unit is an explosimeter. It is located between the secondary activated carbon unit and the blowers. If, due to short circuiting or other malfunctions, vapor passes through the activated carbon untreated, the explosimeter will monitor the VOC level prior to the air stream's entry into the blowers. At 10 percent of the lower explosive limit (LEL), the dead-man system shuts the ISVS unit down, decreasing the possibility of fire or explosion. The system has to be restarted manually. See Figures 12-1 and 12-2 for schematics of the ISVS mobile unit.

Hearing protection is required inside the ISVS mobile unit when the blowers are in operation. Several types of hearing protection devices are provided in the unit. A first-aid kit and ABC fire extinguisher are also located inside the mobile unit. Although the unit is equipped with its own cooling system, it is not designed for continuous occupancy. Work spaces are available for brief periods of activity inside the unit.

Hazards associated with the ISVS unit are mainly slips, trips, and falls. Prevention measures that can be taken in order to avoid such hazards are: (1) proper installation of the ISVS mobile unit; (2) taking precautions when entering and exiting the ISVS mobile unit; and (3) maintaining the floor inside the unit free of water, debris, and other materials that could cause slippage.

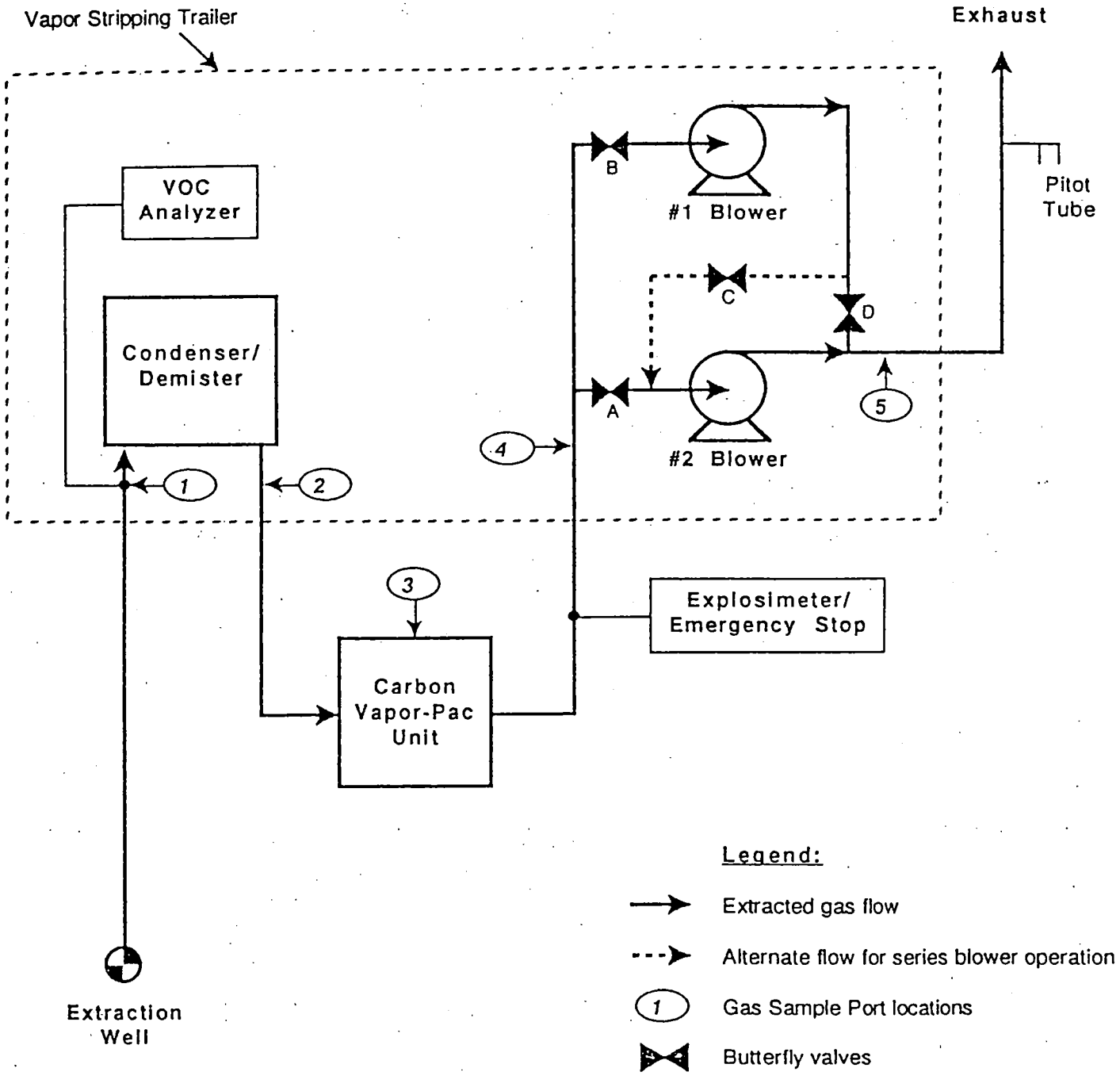


Figure 12-1 Pilot-Scale In Situ Vapor Stripping System Flow Schematic

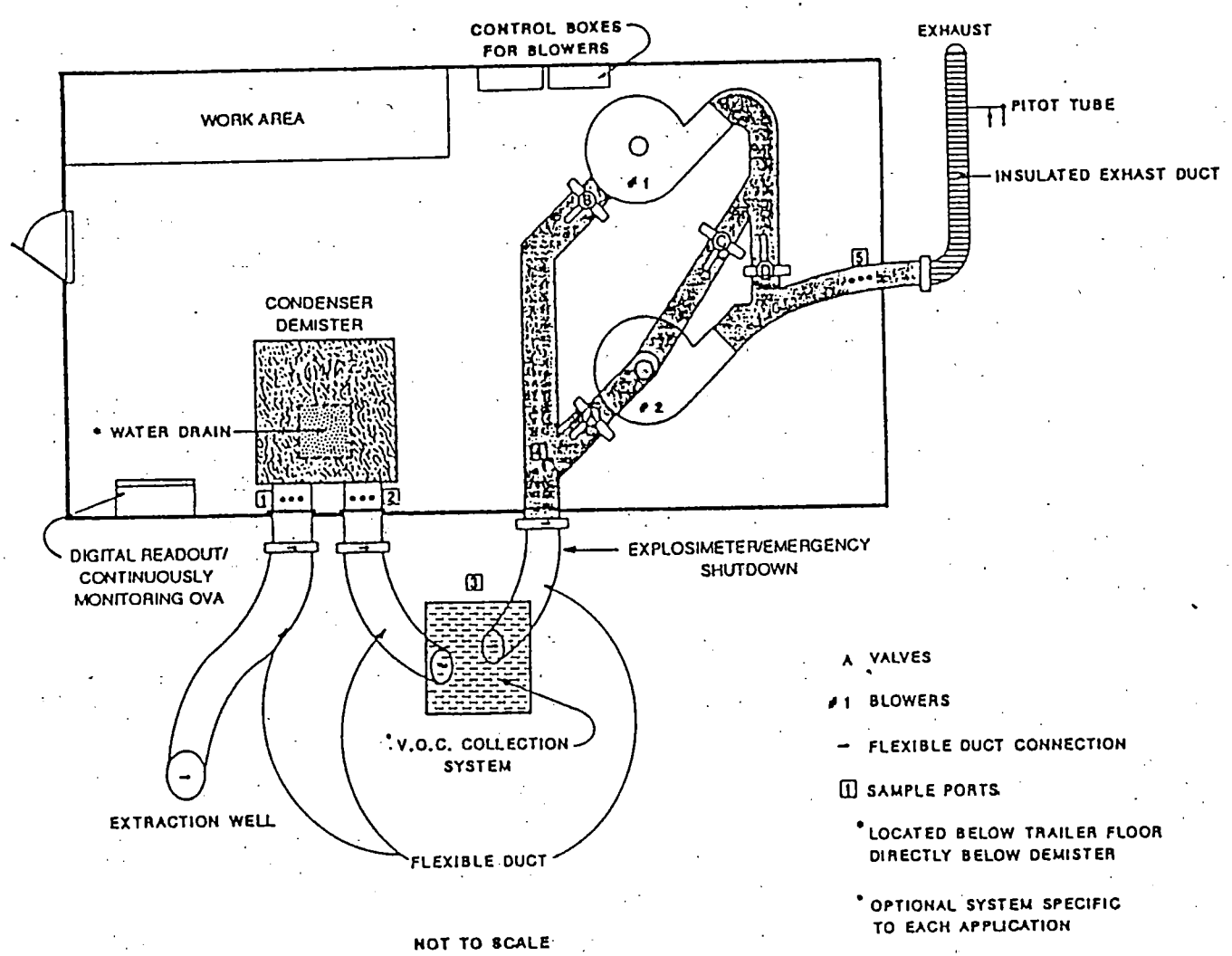


FIGURE 12-2LAYOUT OF IN-SITU VAPOR STRIPPING PILOT SCALE TRAILER

The ISVS mobile unit is designed so that the air flow is on the vacuum side when VOCs are present in the air stream. This configuration was selected to prevent exposure should a leak occur. If the ISVS system should develop a leak, the flow is from the ambient air into the VOC air stream flow. This would cause dilution of the air stream and there would be no buildup of possibly hazardous materials in or around the unit. If the vacuum system should leak on the exhaust side, the leaking air would consist of "VOC stripped air" that had already been treated by the activated carbon system and would contain safe levels of volatile organic constituents.

ADDENDUM 1

MATERIAL SAFETY DATA SHEETS

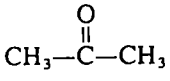
OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR ACETONE

INTRODUCTION

This guideline summarizes pertinent information about acetone for workers, employers, and occupational safety and health professionals who may need such information to conduct effective programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

- **Formula:** C_3H_6O
- **Structure:**



- **Synonyms:** Dimethyl ketone, ketone propane, propanone, 2-propanone
- **Identifiers:** CAS 67-64-1; RTECS AL3150000; DOT 1090, label required: "Flammable Liquid"
- **Appearance and odor:** Colorless liquid with a fragrant, mintlike odor

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 58.09
2. Boiling point (at 760 mmHg): 56.2 °C (133 °F)
3. Specific gravity (water = 1): 0.79
4. Vapor density (air = 1 at boiling point of acetone): 2.0
5. Melting point: -94.8 °C (-138 °F)
6. Vapor pressure at 20 °C (68 °F): 180.0 mmHg; at 25 °C (77 °F), 226.3 mmHg
7. Miscible in water
8. Evaporation rate (butyl acetate = 1): 6
9. Saturation concentration in air (approximate) at 20 °C (68 °F): 23.7 % (237,000 ppm); at 25 °C (77 °F), 29.8 % (298,000 ppm)
10. Ionization potential: 9.69 eV

- **Reactivity**

1. Incompatibilities: Contact with acids and oxidizing materials may cause fires and explosions.
2. Hazardous decomposition products: Toxic vapors and gases (e.g., ketene) may be released in a fire involving acetone.
3. Caution: Acetone will dissolve most plastics, resins, and rubber.

- **Flammability**

1. Flash point: -18.0 °C (0 °F) (closed cup)
2. Autoignition temperature: 465 °C (869 °F)
3. Flammable limits in air, % by volume: Lower, 2.2; Upper, 13
4. Extinguishant: Carbon dioxide, dry chemical, or alcohol foam
5. Class IB Flammable Liquid (29 CFR 1910.106), Flammability Rating 3 (NFPA)

- **Warning properties**

1. Odor threshold: 20 ppm
2. Eye irritation levels: Acetone has been reported to cause a burning sensation of the eyes at a vapor concentration of 500 ppm. Other reports have concluded that irritation in acclimated workers occurs between 1,000 and 1,500 ppm.
3. Evaluation of warning properties for respirator selection: Because of its odor, acetone can be detected below the National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL); thus, it is treated as a chemical with adequate warning properties.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for acetone is 1,000 parts of acetone per million parts of air (ppm) [2,400 milligrams of acetone per cubic meter of air (mg/m^3)] as a time-weighted average (TWA) concentration over an 8-hour workshift. The NIOSH REL is 250 ppm (590 mg/m^3) as a TWA for up to a 10-hour workshift, 40-hour workweek. The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV®) is 750 ppm (1,780 mg/m^3) as a TWA for a normal 8-hour workday and a 40-hour workweek; the (ACGIH) short-term exposure limit (STEL) is 1,000 ppm (2,375 mg/m^3) (Table 1).

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

Table 1.—Occupational exposure limits for acetone

	Exposure limits ppm	mg/m³
OSHA PEL TWA	1,000	2,400
NIOSH REL TWA	250	590
ACGIH TLV® TWA	750	1,780
STEL	1,000	2,375

HEALTH HAZARD INFORMATION

• **Routes of exposure**

Acetone may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.

• **Summary of toxicology**

1. *Effects on animals:* Acute inhalation of acetone produced depression of respiration and narcosis in rats. Subchronic dermal application or subcutaneous injection of acetone produced cataracts in guinea pigs.

2. *Effects on humans:* Acute inhalation of acetone has produced narcosis, and repeated exposures have caused inflammation of the respiratory tract, stomach, and small intestine. Studies of persons clinically exposed indicate that acetone is metabolized slowly and may accumulate in the body throughout a 40-hour workweek.

• **Signs and symptoms of exposure**

1. *Short-term (acute):* Exposure to acetone can cause eye irritation, dryness of the mouth and throat, nausea, vomiting, headache, sleepiness, dizziness, light-headedness, weakness, incoordination, loss of energy, fainting, and unconsciousness.

2. *Long-term (chronic):* Exposure to acetone can cause dizziness and sleepiness. Dryness, irritation, and inflammation of skin can also occur.

RECOMMENDED MEDICAL PRACTICES

• **Medical surveillance program**

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, morbidity, and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• **Preplacement medical evaluation**

Prior to placing a worker in a job with a potential for exposure to acetone, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the skin, eyes, and nervous and respiratory systems. Medical surveillance for respiratory disease should be conducted by using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to acetone at or below the NIOSH REL. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include a history of chronic skin disease or concurrent dermatitis.

• **Periodic medical screening and/or biologic monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to acetone. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the physiologic function of the skin, eyes, and nervous and respiratory systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population. The following tests should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH and ATS: standardized questionnaires and tests of lung function.

• **Medical practices recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population.

• **Sentinel health events**

Acute SHE's include: Contact and/or allergic dermatitis.

MONITORING AND MEASUREMENT PROCEDURES

• **TWA exposure evaluation**

Measurements to determine worker exposure to acetone should be taken so that the TWA exposure is based on a single entire workshift sample or an appropriate number of consecutive samples collected during the entire workshift. Under certain conditions, it may be appropriate to collect several short-term interval samples (up to 30 minutes each) to determine the average exposure level. Air samples should be taken in the worker's breathing zone (air that most nearly represents that inhaled by the worker).

• **Method**

Sampling and analysis may be performed by collecting acetone vapors with charcoal tubes followed by desorption with carbon disulfide and analysis by gas chromatography. Detector tubes or other direct-reading devices calibrated to measure acetone may also be used if available. A detailed sampling and analytical method for acetone may be found in the *NIOSH Manual of Analytical Methods* (method number 1300).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, face shields (8-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with acetone.

Workers should be provided with and required to use splash-proof safety goggles where acetone may come in contact with the eyes.

SANITATION

Clothing which is contaminated with acetone should be removed immediately and placed in closed containers for storage until it can be discarded or until provision is made for the removal of acetone from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of acetone's hazardous properties.

Change and shower rooms should be provided with separate locker facilities for street and work clothes.

Skin that becomes contaminated with acetone should be promptly washed with soap and water.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or application of cosmetics, the storage or smoking of tobacco or other smoking materials, or the storage or use of products for chewing should be prohibited in work areas.

Workers who handle acetone should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to acetone may occur and control methods which may be effective in each case are listed in Table 2.

Table 2.—Operations and methods of control for acetone

Operations	Controls
During application of lacquer, paints, and varnishes	Natural ventilation, local exhaust ventilation, workroom ventilation, personal protective equipment
During use of solvents and cementing agents	Personal protective equipment
During dip application of protective coatings; during cleaning operations	Local exhaust ventilation, personal protective equipment
During fabric coating and dyeing processes	Local exhaust ventilation, general dilution ventilation, personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures.

• **Eye exposure**

Where there is any possibility of a worker's eyes being exposed to acetone, an eye-wash fountain should be provided within the immediate work area for emergency use.

If acetone gets into the eyes, flush them immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• **Skin exposure**

Where there is any possibility of a worker's body being exposed to acetone, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If acetone gets on the skin, wash it immediately with soap and water. If acetone penetrates the clothing, remove the clothing immediately and wash the skin with soap and water. If irritation persists after washing, get medical attention promptly.

• **Rescue**

If a worker has been incapacitated, move the affected worker from the hazardous exposure. Put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILLS AND LEAKS

In cases in which environmental levels exceed the NIOSH REL, workers not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

If acetone is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities of liquids containing acetone, absorb on paper towels and place in an appropriate container. Place towels in a safe place such as a fume hood for evaporation. Allow sufficient time for evaporation of the vapors so that the hood ductwork is free from acetone vapors. Burn the paper in a suitable location away from combustible materials.
4. Large quantities of liquids containing acetone may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container. Acetone should not be allowed to enter a confined space such as a sewer because of the possibility of an explosion.
5. Liquids containing acetone may be collected by vacuuming with an appropriate system. If a vacuum system is used, there should be no sources of ignition in the vicinity of the spill, and flashback prevention devices should be provided.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards, 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

For each level of respiratory protection, only those respirators that have the minimum required protection factor and meet other use restrictions are listed. All respirators that have higher protection factors may also be used.

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Table 3.—Respiratory protection for acetone

Condition	Minimum respiratory protection*†
Concentration:	
Less than or equal to 1,000 ppm	Any chemical cartridge respirator with organic vapor cartridge(s)
	Any powered air-purifying respirator with organic vapor cartridge(s)
	Any supplied-air respirator
	Any self-contained breathing apparatus
Less than or equal to 6,250 ppm	Any supplied-air respirator operated in a continuous flow mode (substance reported to cause eye irritation or damage—may require eye protection)
Less than or equal to 12,500 ppm	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister
	Any supplied-air respirator with a full facepiece
	Any self-contained breathing apparatus with a full facepiece
Less than or equal to 20,000 ppm	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown concentrations or levels above 20,000 ppm	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister
	Any appropriate escape-type self-contained breathing apparatus

* Only NIOSH/MSHA-approved equipment should be used.
†The respiratory protection listed for any given condition is the minimum required to meet the NIOSH REL of 250 ppm (590 mg/m³) (TWA).

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR INORGANIC ARSENIC AND ITS COMPOUNDS (as As) POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

"Inorganic arsenic" is defined as elemental arsenic and all of its inorganic compounds except arsine (see guideline for arsine). This guideline summarizes pertinent information about inorganic arsenic for workers, employers, and occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

Data in the following section are presented for elemental arsenic.

- **Formula:** As
- **Synonyms:** Arsenic black, arsenic-75, arsenic solid, arsenic metallic, arsenicals, grey arsenic
- **Identifiers:** CAS 7440-38-2; RTECS CG0525000; DOT 1558, label required: "Poison"
- **Appearance and odor:** Gray metal with an odor like garlic when heated

CHEMICAL AND PHYSICAL PROPERTIES

Data in the following section are presented for elemental arsenic.

- **Physical data**

1. Molecular weight: 74.92
2. Boiling point (at 760 mmHg): 613°C (1,135°F), sublimes
3. Specific gravity (water = 1): 5.73
4. Vapor density (air = 1 at sublimation point of arsenic): 2.6
5. Melting point: Sublimes at 613°C (1,135°F)
6. Insoluble in water

- **Reactivity**

1. Incompatibilities: Oxidizing agents and heat
2. Hazardous decomposition products: Toxic gases and vapors or fumes (e.g., arsenic oxide fume) may be released in a fire involving arsenic.
3. Caution: Hydrogen gas can react with inorganic arsenic to form arsine.

- **Flammability**

1. Extinguishant: All firefighting agents, except soda-acid
2. Caution: Arsenic is combustible in powder form or by chemical reaction with powerful oxidizers such as bromates, chlorates, iodates, and peroxides.

- **Warning properties**

Evaluation of warning properties for respirator selection: Warning properties are not considered in recommending respirators for use with carcinogens.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for inorganic arsenic (except arsine) is 0.01 milligrams of arsenic per cubic meter of air (mg/m^3) as a time-weighted average (TWA) over an 8-hour workshift. The National Institute for Occupational Safety and Health (NIOSH) recommends that arsenic and all its inorganic compounds be controlled and handled as potential human carcinogens in the workplace and that exposure be minimized to the lowest feasible limit. The NIOSH recommended exposure limit (REL) for arsenic and all its inorganic compounds is 0.002 mg/m^3 as a ceiling concentration determined in any 15-minute sampling period. The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV®) for soluble arsenic compounds is 0.2 mg/m^3 as a TWA for a normal 8-hour workday and a 40-hour workweek. The ACGIH has designated arsenic trioxide production as A2 (suspected human carcinogen) without having sufficient evidence to assign a TLV® (Table 1).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Inorganic arsenic compounds may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

Table 1.—Occupational exposure limits for inorganic arsenic and its compounds (as As)

	Arsenic and its inorganic compounds	Arsenic compounds, soluble	Arsenic trioxide production
	mg/m³	mg/m³	mg/m³
OSHA PEL TWA	0.01	—	—
NIOSH REL (Ca)*			
Ceiling (15 min)	0.002	—	—
ACGIH TLV® (TWA)	—	0.2	(A2)†

* (Ca): NIOSH recommends treating as a potential human carcinogen.
† (A2): Suspected human carcinogen.

• **Summary of toxicology**

1. *Effects on animals:* Chronic ingestion or inhalation of inorganic arsenic by rats caused marked enlargement of the common bile duct and fatty degeneration of the liver. Injection of arsenic in pregnant rats, mice, and hamsters caused malformations of the offspring.

2. *Effects on humans:* Inhalation, ingestion, or dermal exposure of workers to inorganic arsenic has caused peripheral nerve inflammation (neuritis) and degeneration (neuropathy), reduced peripheral circulation, anemia, increased mortality due to cardiovascular failure, and cancers of the skin, lungs, and lymphatic system.

• **Signs and symptoms of exposure**

1. *Short-term (acute):* Exposure to inorganic arsenic can cause nausea, vomiting, diarrhea, weakness, loss of appetite, cough, chest pain, giddiness, headache, and breathing difficulty (dyspnea).

2. *Long-term (chronic):* Exposure to inorganic arsenic can cause weakness, nausea, vomiting, diarrhea, skin and eye irritation, hyperpigmentation, thickening of the palms and soles (hyperkeratosis), contact dermatitis, skin sensitization, warts, ulceration and perforation of the nasal septum, and numbness and weakness in the legs and feet.

RECOMMENDED MEDICAL PRACTICES

• **Medical surveillance program**

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevent environmental and biologic monitoring, medical screening, morbidity, and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• **Preplacement medical evaluation**

Prior to placing a worker in a job with a potential for exposure to inorganic arsenic, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the skin, peripheral nervous system, liver, lymphatic and hematopoietic (blood cell forming) systems, and respiratory tract. Medical surveillance for respiratory disease should be conducted by using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to inorganic arsenic and its compounds at or below the NIOSH REL. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include concurrent dermatitis or peripheral neuropathy, a history and other findings consistent with chronic disease of the skin or nervous system, and significant breathing impairment due to preexisting chronic lung disease.

• **Periodic medical screening and/or biologic monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to inorganic arsenic. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the physiologic function of the skin, blood, lymphatic system, peripheral nervous system, liver, and respiratory tract as compared to the baseline status of the individual worker or to expected values for a suitable reference population. The following tests should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH

and ATS: standardized questionnaires and tests of lung function.

• **Medical practices recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population. Because occupational exposure to inorganic arsenic and its compounds may cause diseases of prolonged induction-latency, the need for medical surveillance may extend well beyond termination of employment.

• **Sentinel health events**

Delayed-onset SHE's include: Inflammatory and toxic neuropathy, agranulocytosis or neutropenia (absense or a severe decrease in the number of certain white blood cells), and cancers of the liver and respiratory tract.

MONITORING AND MEASUREMENT PROCEDURES

• **Ceiling concentration evaluation**

Measurements to determine worker exposure should be taken during periods of maximum expected airborne concentrations of inorganic arsenic. Each measurement to determine the NIOSH REL (ceiling exposure) in the worker's breathing zone (air that most nearly represents that inhaled by the worker) should consist of a 15-minute sample or a series of consecutive samples that total 15 minutes. A minimum of three measurements should be taken during one workshift, and the highest of all measurements taken is an estimate of the worker's exposure. If the periods of maximum exposure are not clearly defined, a statistical procedure which can be used as a peak exposure detection strategy is given in the *Occupational Exposure Sampling Strategy Manual.*

• **Method**

Sampling and analysis may be performed by collecting particulate inorganic arsenic with cellulose membrane filters followed by digestion with acid and analysis by atomic absorption with flame arsine generation. A detailed sampling and analytical method may be found in the *NIOSH Manual of Analytical Methods* (method number 7900).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, and other appropriate protective clothing necessary to prevent skin contact with inorganic arsenic.

SANITATION

Clothing which is contaminated with inorganic arsenic should be removed immediately and placed in sealed containers for storage until it can be discarded or until provision is made for the removal of inorganic arsenic from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of inorganic arsenic's hazardous properties. Reusable clothing and equipment should be checked for residual contamination before reuse or storage.

A change room with showers, washing facilities, and lockers that permit separation of street and work clothes should be provided.

Workers should be required to shower following a workshift and prior to putting on street clothes. Clean work clothes should be provided daily.

Skin that becomes contaminated with inorganic arsenic should be promptly washed with soap and water.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or application of cosmetics, the storage or smoking of tobacco or other smoking materials, and the storage or use of products for chewing should be prohibited in work areas.

Workers who handle inorganic arsenic should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to inorganic arsenic may occur and control methods which may be effective in each case are listed in Table 2.

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures.

• **Eye exposure**

Where there is any possibility of a worker's eyes being exposed to inorganic arsenic, an eyewash fountain should be provided within the immediate work area for emergency use.

If inorganic arsenic gets into the eyes, flush them immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• **Skin exposure**

Where there is any possibility of a worker's body being exposed to inorganic arsenic, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If inorganic arsenic gets on the skin, wash it immediately with soap and water. If inorganic arsenic penetrates the clothing, remove the clothing promptly and wash the skin with soap and water. Get medical attention promptly.

Table 2.—Operations and methods of control for inorganic arsenic

Operations	Controls
During the manufacture of insecticides, weed killers and fungicides; during use as a wood preservative	Process enclosure, local exhaust ventilation, personal protective equipment
During use in the manufacture and handling of calcium arsenate; during use in the manufacture of electrical semiconductors, diodes, and solar batteries	Process enclosure, local exhaust ventilation, personal protective equipment
During use as a bronzing or decolorizing addition in glass manufacturing; during use in the production of opal glass and enamels	Process enclosure, local exhaust ventilation, personal protective equipment
During use as an addition to alloys to increase hardening and heat resistance	Process enclosure, local exhaust ventilation, personal protective equipment
During smelting of ores	Local exhaust ventilation, personal protective equipment

• **Rescue**

If a worker has been incapacitated, move the affected worker from the hazardous exposure. Put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILLS AND LEAKS

Workers not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

If inorganic arsenic or its compounds are spilled, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill.
3. For small quantities of liquids containing inorganic arsenic, absorb on paper towels and place in an appropriate container.
4. Large quantities of liquids containing inorganic arsenic may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container.
5. Inorganic arsenic dust may be collected by vacuuming with an appropriate high-efficiency fitration system. If a vacuum system is used, there should be no sources of ignition in the vicinity of the spill, and flashback prevention devices should be provided.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

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Table 3.—Respiratory protection for inorganic arsenic

Condition	Minimum respiratory protection*
Any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown or any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted acid gas canister having a high-efficiency particulate filter
	Any appropriate escape-type self-contained breathing apparatus

* Only NIOSH/MSHA-approved equipment should be used.

Occupational Health Guideline for Soluble Barium Compounds (as Barium)

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

APPLICABILITY

The general guidelines contained in this document apply to all soluble barium compounds. Physical and chemical properties of several specific compounds are provided for illustrative purposes.

SUBSTANCE IDENTIFICATION

Barium nitrate

- Formula: $Ba(NO_3)_2$
- Synonyms: None
- Appearance and odor: Odorless white solid.

Barium oxide

- Formula: BaO
- Synonyms: None
- Appearance and odor: Odorless white solid.

Barium carbonate

- Formula: $BaCO_3$
- Synonyms: None
- Appearance and odor: Odorless white solid.

Barium chloride

- Formula: $BaCl_2$
- Synonyms: None
- Appearance and odor: Odorless white solid.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for soluble barium compounds is 0.5 milligram of soluble barium compounds per cubic meter of air (mg/m^3) averaged over an eight-hour work shift.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Soluble barium compounds can affect the body if they are inhaled or if they come in contact with the eyes or skin. They can also affect the body if they are swallowed.

- **Effects of overexposure**

1. Short-term Exposure: Soluble barium compounds may cause local irritation of the eyes, nose, throat, bronchial tubes, and skin. Soluble barium compounds may also cause severe stomach pains, slow pulse rate, irregular heart beat, ringing of the ears, dizziness, convulsions, and muscle spasms. Death may occur.

2. Long-term Exposure: None known

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to soluble barium compounds.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to soluble barium compounds at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the heart, lungs, and nervous system should be stressed. The skin should be examined for evidence of chronic disorders.

—14" x 17" chest roentgenogram: Soluble barium compounds cause human lung damage. Surveillance of the lungs is indicated.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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Occupational Safety and Health Administration

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—FVC and FEV (1 sec): Soluble barium compounds are respiratory irritants. Persons with impaired pulmonary function may be at increased risk from exposure. Periodic surveillance is indicated.

—Electrocardiogram: Barium compounds may cause cardiac arrhythmias and may have a direct effect on the cardiac muscle. Periodic surveillance of the heart is indicated.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis, except that an x-ray is necessary only when indicated by the results of pulmonary function testing, or by signs and symptoms of respiratory disease.

• **Summary of toxicology**

Soluble barium salts cause severe gastroenteritis and systemic effects by ingestion. Intravenous injection of barium compounds in animals causes a strong, prolonged stimulation of muscle resulting in hyperperistalsis, bladder contraction, vasoconstriction, and irregular contraction of the heart followed by arrest in systole. Animals also exhibit stimulation of the central nervous system followed by paralysis. Ingestion of barium carbonate by humans causes gastroenteritis, muscular paralysis, slow pulse rate, extrasystoles, and hypokalemia. Heavy industrial exposure to dusts of barium sulfate or barium oxides may produce a benign pneumoconiosis, termed baritosis. It results in no impairment of ventilatory function, although signs of mild bronchial irritation may occur. Characteristic x-ray changes are those of small, dense, circumscribed nodules evenly distributed throughout the lung fields, reflecting the radio-opacity of the barium dust. Bronchial irritation has been reported from the inhalation of barium carbonate dust. Barium hydroxide and barium oxide are strongly alkaline in aqueous solution, causing severe burns of the eye and irritation of the skin.

CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data—Barium nitrate**

1. Molecular weight: 261.4
2. Boiling point (760 mm Hg): Greater than 592 C (greater than 1098 F) (decomposes)
3. Specific gravity (water = 1): 3.24
4. Vapor density (air = 1 at boiling point of barium nitrate): Not applicable
5. Melting point: 592 C (1098 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 9.2
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Barium oxide**

1. Molecular weight: 153.3
2. Boiling point (760 mm Hg): 2000 C (3632 F)
3. Specific gravity (water = 1): 5.72
4. Vapor density (air = 1 at boiling point of barium oxide): Not applicable
5. Melting point: 1921 C (3490 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): Reacts
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Barium carbonate**

1. Molecular weight: 197.3
2. Boiling point (760 mm Hg): 1300 C (2372 F) (decomposes)
3. Specific gravity (water = 1): 4.25
4. Vapor density (air = 1 at boiling point of barium carbonate): Not applicable
5. Melting point: Decomposes at 1300 C (2372 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 0.0022
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Barium chloride**

1. Molecular weight: 208.3
2. Boiling point (760 mm Hg): 1560 C (2840 F)
3. Specific gravity (water = 1): 3.86
4. Vapor density (air = 1 at boiling point of barium chloride): Not applicable
5. Melting point: 963 C (1765 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 36
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Reactivity**

1. Conditions contributing to instability: For barium nitrate, elevated temperatures may cause melting and decomposition; for the other compounds, none hazardous.
2. Incompatibilities: Contact of barium oxide with water, carbon dioxide, or hydrogen sulfide may cause fires and explosions. Contact of barium carbonate with acids causes formation of carbon dioxide gas that may cause suffocation in enclosed spaces. Contact of barium nitrate with organic matter and combustible materials may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as oxides of nitrogen and carbon monoxide) may be released in a fire involving barium nitrate.
4. Special precautions: None

• **Flammability**

1. Flash point: Not applicable
2. Autoignition temperature: For barium nitrate, data not available; for the the other compounds, not applicable.
3. Flammable limits in air, % by volume: Not applicable
4. Extinguishant: Large amounts of water should be used on adjacent fires.

• **Warning properties**

According to Grant, barium chloride causes "considerable iritis, which subsides in a few days" when "tested

in neutral 0.08 to 0.1 M solution on rabbit eyes by injection into the cornea or by dropping for 10 minutes on the eye after the corneal epithelium was removed to facilitate penetration." Grant states that "both the oxide and hydroxide are capable of causing severe alkali burns of the eye, similar to those produced by calcium hydroxide."

MONITORING AND MEASUREMENT PROCEDURES

• General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Method

Sampling and analyses may be performed by collection on a cellulose membrane filter followed by leaching in hot water, solution of sample in acid, and analysis in an atomic absorption spectrophotometer. An analytical method for soluble barium compounds is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with barium carbonate, barium chloride, barium nitrate, or liquids containing these compounds.

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with barium oxide or liquids containing barium oxide, where skin contact may occur.

• If employees' clothing has had any possibility of being contaminated with barium carbonate, barium chloride, barium nitrate, barium oxide, or liquids containing these compounds, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing contaminated with barium carbonate, barium chloride, barium nitrate, or barium oxide should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of contaminant from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the contaminant, the person performing the operation should be informed of contaminant's hazardous properties.

• Where exposure of an employee's body to barium oxide or liquids containing barium oxide may occur, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

• Non-impervious clothing which becomes contaminated with barium carbonate, barium chloride, barium nitrate, or barium oxide should be removed promptly and not reworn until the contaminant is removed from the clothing.

• Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of barium oxide or liquids containing barium oxide contacting the eyes.

• Employees should be provided with and required to use dust- and splash-proof safety goggles where barium carbonate, barium chloride, barium nitrate, or liquids containing these compounds may contact the eyes.

• Where there is any possibility that employees' eyes may be exposed to barium oxide or liquids containing barium oxide, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

• Workers subject to skin contact with barium oxide or liquids containing barium oxide should wash any areas of the body which may have contacted barium oxide at the end of each work day.

• Skin that becomes contaminated with barium carbonate, barium chloride, or barium nitrate should be promptly washed or showered to remove any contaminant. In the case of barium carbonate, employees should use soap or mild detergent and water for washing purposes.

• Skin that becomes contaminated with barium oxide should be promptly washed or showered to remove any barium oxide from the skin after all obvious amounts of barium oxide have been removed by other means (e.g., by use of oil or vaseline). Employees who are being burned by barium oxide should immediately utilize quick drenching facilities without first removing barium oxide by other means.

• Eating and smoking should not be permitted in areas where solid barium carbonate, barium chloride, barium nitrate, or barium oxide, or liquids containing these compounds are handled, processed, or stored.

• Employees who handle barium carbonate, barium chloride, barium nitrate, barium oxide, or liquids containing these compounds should wash their hands thoroughly before eating, smoking, or using toilet facilities. In the case of barium carbonate, employees should use soap or mild detergent and water for washing purposes.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to soluble barium compounds may occur and control methods which may be effective in each case:

Operation	Controls
Manufacture and distribution of soluble barium compounds	Process enclosure; local exhaust ventilation
Use in manufacture of pressed and blown glasssware and flint and crown optical glass; manufacture of ceramic products; use in electronics industry in manufacture of magnets, vacuum tubes, cathodes, x-ray fluorescent screens, TV picture tubes, and dry cell depolarizers	Process enclosure; local exhaust ventilation
Use in manufacture of photographic papers, dyes, and chemicals	Process enclosure; local exhaust ventilation
Use as pesticides, rodenticides, and disinfectants; use in manufacture of explosives, matches, and pyrotechnics as igniter compositions and fireworks	Process enclosure; local exhaust ventilation
Use as an additive in manufacture of grease, and manufacture of lubricating oils; use in refining of vegetable and animal oils	Process enclosure; local exhaust ventilation
Use in case-hardening of steel in metallurgy; in welding aluminum; in electroplating; and in aluminum and sodium refining	Process enclosure; local exhaust ventilation
Use in water treatment and boiler compounds for softening water; use as catalysts, analytical reagents, and purifying agents	Process enclosure; local exhaust ventilation
Use for treatment of textiles, leather, and rubber; use in manufacture of paper and cellulose as a bleaching agent; use in manufacture of pigments, colors, and lakes	Process enclosure; local exhaust ventilation
Use as a depilatory in processing of hides; as a fire-proof and extinguishing agent; in embalming; in sugar refining; in gas and solvent drying; in marble substitutes; in valve manufacture; and as a smoke suppressant in diesel fuels	Process enclosure; local exhaust ventilation
Use in manufacture of pigments, paints, enamels, and printing inks	Process enclosure; local exhaust ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If solutions of barium compounds get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with these chemicals.

• **Skin Exposure**

If solutions of barium compounds get on the skin, immediately flush the contaminated skin with water. If solutions of barium compounds soak through the clothing, remove the clothing immediately and flush the skin with water. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of soluble barium compounds, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When soluble barium compounds have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills until cleanup has been completed.

• If soluble barium compounds are spilled, the following steps should be taken:

1. Ventilate area of spill.
2. Collect spilled material in the most convenient and safe manner and deposit in sealed containers for reclamation or for disposal in a secured sanitary landfill. Liquids containing soluble barium compounds should be absorbed in vermiculite, dry sand, earth, or a similar material.

• Waste disposal method:

Soluble barium compounds may be disposed of in sealed containers in a secured sanitary landfill.

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RESPIRATORY PROTECTION FOR SOLUBLE BARIUM COMPOUNDS (AS BARIUM)

Condition	Minimum Respiratory Protection* Required Above 0.5 mg/m³
Particulate Concentration	
2.5 mg/m³ or less	Any dust and mist respirator, except single-use.**
5 mg/m³ or less	Any dust and mist respirator, except single-use or quarter-mask respirator. Any fume respirator or high efficiency particulate filter respirator. Any supplied-air respirator. Any self-contained breathing apparatus.
25 mg/m³ or less	A high efficiency particulate filter respirator with a full facepiece. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
250 mg/m³ or less	A Type C supplied-air respirator operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode. A powered air-purifying respirator with a high efficiency particulate filter.
Greater than 250 mg/m³ or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	A high efficiency particulate filter respirator. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

**If eye irritation occurs, full-facepiece respiratory protective equipment should be used.

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR BENZENE

POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

This guideline summarizes pertinent information about benzene for workers, employers, and occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

- **Formula:** C_6H_6
- **Structure:**

- **Synonyms:** Benzol, benzole, benzolene, bicarburet of hydrogen, carbon oil, coal naphtha
- **Identifiers:** CAS 71-43-2; RTECS CY1400000; DOT 1114, label required: "Flammable Liquid"
- **Appearance and odor:** Colorless liquid with an aromatic odor

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 78.12
2. Boiling point (at 760 mmHg): 80.1°C (176°F)
3. Specific gravity (water = 1): 0.88
4. Vapor density (air = 1 at boiling point of benzene): 2.7
5. Melting point: 5.5°C (42°F)
6. Vapor pressure at 20°C (68°F): 75 mmHg
7. Solubility in water, g/100 g water at 20°C (68°F): 0.06
8. Evaporation rate (butyl acetate = 1): 5.1
9. Saturation concentration in air (approximate) at 25°C (77°F): 12.5% (125,000 ppm)
10. Ionization potential: 9.25 eV

- **Reactivity**

Incompatibilities: Benzene reacts with strong oxidizers including chlorine, oxygen, and bromine with iron.

2. Hazardous decomposition products: Toxic vapors and gases (e.g., carbon monoxide) may be released in a fire involving benzene.
3. Caution: Benzene will attack some forms of plastics, coatings, and rubber.

- **Flammability**

1. Flash point: -11.1°C (12°F) (closed cup)
2. Autoignition temperature: 498°C (928°F)
3. Flammable limits in air, % by volume: Lower, 1.4; upper, 7.1
4. Extinguishant: Alcohol foam, carbon dioxide, and dry chemical extinguishants are effective. Water may be an ineffective extinguishant but may be used to cool fire-exposed containers.
5. Class IB Flammable Liquid (29 CFR 1910.106), Flammability Rating 3 (NFPA)
6. Unusual fire and explosion hazards: Benzene liquid is flammable, and its vapors can easily form explosive mixtures. Flashbacks may occur along a vapor trail.

- **Warning properties**

1. Odor threshold: 12 ppm
2. Eye irritation levels: 3,000 ppm for 0.5-1 hour
3. Other information: 3,000 ppm may irritate nose and respiratory tract.
4. Evaluation of warning properties for respirator selection: Warning properties are not considered in recommending respirators for use with carcinogens.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for benzene is 1 part of benzene per million parts of air (PPM) as a time-weighted average (TWA) concentration over an 8-hour workshift; the short-term exposure limit is 5 ppm in any 15-minute sampling period. The National Institute for Occupational Safety and Health (NIOSH) recommends that benzene be controlled and handled as a potential human carcinogen in the workplace and that exposure be reduced to the lowest feasible limit. The NIOSH recommended exposure limit (REL) is 0.1 ppm [0.32 milligrams of benzene per cubic meter of air (mg/m^3)] as an 8-hour TWA and 1 ppm (3.2 mg/m^3) as a ceiling in any 15-minute sampling period. The NIOSH REL is the lowest con-

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

centration detectable by current NIOSH-validated sampling and analytical methods. The American Conference of Governmental Industrial Hygienists (ACGIH) has designated benzene as an A2 substance (suspected human carcinogen) having an assigned threshold limit value (TLV®) of 10 ppm (30 mg/m³) as a TWA for a normal 8-hour workday and a 40-hour workweek.

Table 1.—Occupational exposure limits for benzene

	Exposure limits	
	ppm	mg/m³
OSHA PEL TWA	1	—
Short-term exposure limit (15 min)	5	—
NIOSH REL (Ca)* TWA	0.1	0.32
Ceiling (15 min)	1	3.2
ACGIH TLV® TWA (A2)†	10	30

* (Ca): NIOSH recommends treating as a potential human carcinogen.
†(A2): Suspected human carcinogen.

HEALTH HAZARD INFORMATION

• **Routes of exposure**
Benzene may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.

• **Summary of toxicology**
1. *Effects on animals:* Acute inhalation of benzene by rats, mice, or rabbits caused narcosis, spontaneous heart contractions (ventricular fibrillation), and death due to respiratory paralysis. Subchronic inhalation of benzene by rats produced decreased white blood cell counts, decreased bone marrow cell activity, increased red blood cell activity, and cataracts. In rats, chronic inhalation or oral administration of benzene produced cancers of the liver, mouth, and Zymbal gland. Inhalation of benzene by pregnant rats caused retardation of fetal development and increased fetal mortality.
2. *Effects on humans:* Acute inhalation exposure of benzene has caused nerve inflammation (polyneuritis), central nervous system depression, and cardiac sensitization. Chronic exposure to benzene has produced anorexia and irreversible injury to the blood-forming organs; effects include aplastic anemia and leukemia.

• **Signs and symptoms of exposure**
1. *Short-term (acute):* Exposure to benzene can cause dizziness, euphoria, giddiness, headache, nausea, staggering gait, weakness, drowsiness, respiratory irritation, pulmonary edema and pneumonia, gastrointestinal irritation, convulsions, and paralysis. Benzene can also cause irritation to the skin, eyes, and mucous membranes.
2. *Long-term (chronic):* Exposure to benzene can cause fatigue, nervousness, irritability, blurred vision, and labored breathing. Repeated skin contact can cause redness, blistering, and dry, scaly dermatitis.

RECOMMENDED MEDICAL PRACTICES

• **Medical surveillance program**
Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, morbidity, and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• **Preplacement medical evaluation**
Prior to placing a worker in a job with a potential for exposure to benzene, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the eyes, skin, liver, and respiratory, nervous, and hematopoietic (blood-cell-forming) systems. The physician should obtain baseline values for the complete blood count and a stained differential count of all blood cell types. Medical surveillance for respiratory disease should be conducted by using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to benzene at or below the NIOSH REL. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindi-

cations to job placement, include a history of chronic skin disease, concurrent dermatitis, or mild non-hemolytic anemia (e.g., mild iron-deficiency anemia).

• **Periodic medical screening and/or biologic monitoring**
Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker report symptoms that may be attributed to exposure to benzene. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the integrity and physiologic function of the skin, liver, and respiratory, nervous, and hematopoietic (blood-cell-forming) systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population. The following tests should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH and the ATS: standardized questionnaires and tests of lung function.

• **Medical practices recommended at the time of job transfer or termination.**
The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population. Because occupational exposure to benzene may cause diseases of prolonged induction-latency, the need for medical surveillance may extend well beyond termination of employment.

• **Sentinel health events**
1. Acute SHE's include: Acute myeloid leukemia and contact and/or allergic dermatitis.
2. Delayed-onset SHE's include: Decrease in the number (neutropenia) or absence (agranulocytosis) of certain white blood cells in the peripheral circulation and/or in the bone marrow (aplastic anemia) and cancer of the red blood cells (erythroleukemia).

MONITORING AND MEASUREMENT PROCEDURES

• **TWA exposure evaluation**
Measurements to determine worker exposure to benzene should be taken so that the TWA exposure is based on a single entire workshift sample or an appropriate number of consecutive samples collected during the entire workshift. Under certain conditions, it may be appropriate to collect several short-term interval samples (up to 30 minutes each) to determine the average exposure level. Air samples should be taken in the worker's breathing zone (air that most nearly represents that inhaled by the worker).

• **Ceiling concentration evaluation**
Measurements to determine worker exposure should be taken during periods of maximum expected airborne concentrations of benzene. Each measurement to determine the NIOSH REL (ceiling exposure) in the worker's breathing zone (air that most nearly represents that inhaled by the worker) should consist of a 15-minute sample. A minimum of three measurements should be taken during one workshift, and the highest of all measurements taken is an estimate of the worker's exposure. If the periods of maximum exposure are not clearly defined, a statistical procedure which can be used as a peak exposure detection strategy is given in the *Occupational Exposure Sampling Strategy Manual*.

• **Method**
Sampling and analysis may be performed by collecting benzene vapors with charcoal tubes followed by desorption with carbon disulfide and analysis by gas chromatography. Direct-reading devices calibrated to measure benzene may also be used if available. A detailed sampling and analytical method for benzene may be found in the *NIOSH Manual of Analytical Methods* (method number 1500).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, and other appropriate protective clothing necessary to prevent skin contact with benzene.

SANITATION

Clothing which is contaminated with benzene should be removed immediately and placed in sealed containers for storage until it can be discarded or until provision is made for the removal of benzene from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of benzene's hazardous properties. Reusable clothing and equipment should be checked for residual contamination before reuse or storage.

A change room with showers, washing facilities, and lockers that permit separation of street and work clothes should be provided.

Workers should be required to shower following a workshift and prior to putting on street clothes. Clean work clothes should be provided daily.

Skin that becomes contaminated with benzene should be promptly washed with soap and water.

Workers who handle benzene should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or application of cosmetics, the storage or use of smoking materials, or the storage or use of products for chewing should be prohibited in work areas.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to benzene may occur and control methods which may be effective in each case are listed in Table 2.

Table 2.—Operations and methods of control for benzene

Operations	Controls
During the manufacture and processing of benzene; during use as a raw material in the production of aromatic compounds and derivatives	Process enclosure, local exhaust ventilation, personal protective equipment
During the use of chemicals in which benzene may be an impurity (e.g., naphthas, toluene, xylene)	Process enclosure, local exhaust ventilation, personal protective equipment
During the manufacture and use of motor fuel blends in which benzene is used as an ingredient; during use as an extracting solvent	Process enclosure (when possible), local exhaust ventilation, personal protective equipment, material substitution
During the preparation and use of paint and varnish removers, rubber cements, and lacquers	Process enclosure (when possible), local exhaust ventilation, personal protective equipment, material substitution

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures.

• **Eye exposure**

Where there is any possibility of a worker's eyes being exposed to benzene, an eye-wash fountain should be provided within the immediate work area for emergency use.

If benzene gets into the eyes, flush them immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• **Skin exposure**

Where there is any possibility of a worker's body being exposed to benzene, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If benzene gets on the skin, wash it immediately with soap and water. If benzene penetrates the clothing, remove the clothing immediately and wash the skin with soap and water. Get medical attention promptly.

• **Rescue**

If a worker has been incapacitated, move the affected worker from the hazardous exposure. Put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILLS AND LEAKS

Workers not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

If benzene is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities of liquids containing benzene, absorb on paper towels and place in an appropriate container.
4. Large quantities of liquids containing benzene may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container.
5. Liquids containing benzene may be collected by vacuuming with an appropriate system. If a vacuum system is used, there should be no sources of ignition in the vicinity of the spill, and flashback prevention devices should be provided.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards, 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

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Table 3.—Respiratory protection for benzene

Condition	Minimum respiratory protection*
Any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown or any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic canister
	Any appropriate escape-type self-contained breathing apparatus

* Only NIOSH/MSHA-approved equipment should be used.

Occupational Health Guideline for Butyl Alcohol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $CH_3CH_2CH_2CH_2OH$
- Synonyms: 1-Butanol; propylcarbinol; n-butanol; n-butyl alcohol; NBA
- Appearance and odor: Colorless liquid with a strong, characteristic odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for butyl alcohol is 100 parts of butyl alcohol per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 300 milligrams of butyl alcohol per cubic meter of air (mg/m^3). The American Conference of Governmental Industrial Hygienists has recommended for butyl alcohol a Threshold Limit Value of 50 ppm as a ceiling value and with a skin notation.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Butyl alcohol can affect the body if it is swallowed, is inhaled, or comes in contact with the skin or eyes.

- **Effects of overexposure**

1. Short-term Exposure: Overexposure to butyl alcohol may cause irritation of the eyes, nose, and throat, headache, dizziness, and drowsiness. The overexposed person may also experience blurred vision and a burning sensation of the eyes, which may last for several days.

2. Long-term Exposure: Drying and cracking of the skin may result from prolonged skin exposure.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to butyl alcohol.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to butyl alcohol at potentially hazardous levels:

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from butyl alcohol exposure.

—Skin disease: Butyl alcohol is a defatting agent and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver disease: Although butyl alcohol is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Kidney disease: Although butyl alcohol is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

—Eye disease: Because butyl alcohol is reported to cause eye injury, those with pre-existing eye disease may be at increased risk.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of butyl alcohol might cause exacerbation of symptoms due to its irritant properties.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

- **Summary of toxicology**

Butyl alcohol is an eye and mucous membrane irritant, and the vapor has a narcotic effect on animals at concentrations in excess of 6000 to 8000 ppm. Also,

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cases of vacuolar keratitis have been reported in humans. Mild narcotic effects have been observed in humans exposed to high concentrations. Mild skin irritation occurs due to defatting action. No chronic systemic effects have been reported in humans.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 74
  2. Boiling point (760 mm Hg): 118 C (244 F)
  3. Specific gravity (water = 1): 0.8
  4. Vapor density (air = 1 at boiling point of butyl alcohol): 2.6
  5. Melting point: −89 C (−128 F)
  6. Vapor pressure at 20 C (68 F): 4.2 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): 7.7
  8. Evaporation rate (butyl acetate = 1): 0.46
- **Reactivity**
  1. Conditions contributing to instability: Heat
  2. Incompatibilities: Contact with strong oxidizers may cause fire and explosions.
  3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving butyl alcohol.
  4. Special precautions: Butyl alcohol will attack some forms of plastics, rubber, and coatings. Butyl alcohol may react with metallic aluminum at high temperatures.
- **Flammability**
  1. Flash point: 28.9 C (84 F) (closed cup)
  2. Autoignition temperature: 365 C (689 F)
  3. Flammable limits in air, % by volume: Lower: 1.4; Upper: 11.2
  4. Extinguishant: Alcohol foam, dry chemical, carbon dioxide
- **Warning properties**
  1. Odor Threshold: Summer and May report an odor threshold of 11 ppm. Patty reports that "Scherberger, Happ, Miller. and Fassett determined that the minimum concentration with identifiable odor of butyl alcohol was 15 ppm."
  2. Eye Irritation Level: The *Documentation of TLV's* states that "Tabershaw et al. reported eye irritation in workmen in concentrations above 55 ppm . . . ." According to Patty, Nelson reported mild eye irritation at 25 ppm. Sterner and associates, however, "revealed little or no irritation or complaints among workers when the average concentration was 100 ppm."
  3. Other Information: Patty states that "Nelson et al. reported mild irritation of the nose, throat, and eyes of subjects briefly exposed to 25 ppm and stated that exposure to 50 ppm was objectionable because it produced irritation of the throat in all subjects and mild headaches in some instances."
  4. Evaluation of Warning Properties: Because of its odor and irritant effects, butyl alcohol is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of butyl alcohol. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

Sampling and analyses may be performed by collection of butyl alcohol vapors using an adsorption tube with subsequent desorption with 2-propanol in carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure butyl alcohol may be used. An analytical method for butyl alcohol is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which

includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid butyl alcohol.
- Clothing wet with liquid butyl alcohol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of butyl alcohol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the butyl alcohol, the person performing the operation should be informed of butyl alcohol's hazardous properties.
- Any clothing which becomes wet with liquid butyl alcohol should be removed immediately and not reworn until the butyl alcohol is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid butyl alcohol may contact the eyes.

SANITATION

- Skin that becomes wet with liquid butyl alcohol should be promptly washed or showered to remove any butyl alcohol.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to butyl alcohol may occur and control methods which may be effective in each case:

Operation	Controls
Use and liberation in spray applications of surface coatings	Local exhaust ventilation; personal protective equipment
Use during brush or dip application of surface coatings	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use in adhesives and as a solvent adhesive in manufacture of garments from fabric coated with polyvinyl butyral	General dilution ventilation; personal protective equipment
Use in leather industry	Local exhaust ventilation; general dilution ventilation
Liberation during manufacture of safety glass; during manufacture of derivatives of butyl aclohol, including chemicals, herbicides, ore flotation agents, urea and melamine formaldehyde resins, and pharmaceuticals	Local exhaust ventilation; general dilution ventilation
Use as a solvent or diluent in manufacture of brake fluids, perfumes, detergents, adhesives, denatured alcohol, and surface coatings	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Liberation during photographic processing operations	Local exhaust ventilation; general dilution ventilation
Use as a swelling agent in textiles	General dilution ventilation
Use as an azeotrophic dehydrating agent and blending agent in laboratory analysis; liberation as a by-product in furfural tetrahydrofuran conversion	General dilution ventilation; local exhaust ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If butyl alcohol gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If butyl alcohol gets on the skin, promptly flush the contaminated skin with water. If butyl alcohol soaks through the clothing, remove the clothing immediately and flush the skin with water. If there is skin irritation, get medical attention.

- **Breathing**

If a person breathes in large amounts of butyl alcohol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When butyl alcohol has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If butyl alcohol is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber. Butyl alcohol should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.

• Waste disposal methods:

Butyl alcohol may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber.

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RESPIRATORY PROTECTION FOR BUTYL ALCOHOL

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
5000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
8000 ppm or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 8000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Cadmium Dust (as Cadmium)*

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

APPLICABILITY

The general guidelines contained in this document apply to all cadmium dust. Physical and chemical properties of several specific compounds are provided for illustrative purposes.

SUBSTANCE IDENTIFICATION

Cadmium metal dust

- Formula: Cd
- Synonyms: None
- Appearance and odor: Odorless, gray powder.

Cadmium oxide dust

- Formula: CdO
- Synonyms: None
- Appearance and odor: Odorless, brown solid or blue-black solid.

Cadmium sulfide dust

- Formula: CdS
- Synonyms: Greenockite
- Appearance: Yellow-orange solid.

Cadmium chloride dust

- Formula: $CdCl_2$
- Synonyms: None
- Appearance: White solid.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for cadmium dust is 0.2 milligram of cadmium dust per cubic meter of air (mg/m^3) averaged over an eight-hour work shift, with a ceiling level of 0.6 mg/m^3. NIOSH has recommended that the permissible exposure limit be reduced to 40 micrograms of cadmium per cubic meter of air ($\mu g/m^3$) averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling level of 200 $\mu g/m^3$ averaged over a 15-minute period. The recommendations in this guideline supplement the recommendations in the NIOSH Criteria Document for Cadmium, which should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Cadmium dust can affect the body if it is inhaled. It can also affect the body if it is swallowed.

- **Effects of overexposure**

1. Short-term Exposure: Cadmium dust may cause irritation of the nose and throat. If enough has been inhaled, after a delay of several hours, a person may also develop cough, chest pain, sweating, chills, shortness of breath, and weakness. Death may occur. Ingestion of cadmium dust may cause nausea, vomiting, diarrhea, and abdominal cramps.

2. Long-term Exposure: Repeated or prolonged exposure to cadmium dust may cause loss of sense of smell, ulceration of the nose, shortness of breath (emphysema), kidney damage, and mild anemia. Exposure to cadmium has also been reported to cause an increased incidence of cancer of the prostate in man. Injections of cadmium sulfate in animals have been reported to cause malformation in their offspring.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to cadmium dust.

- **Recommended medical surveillance**

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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The following medical procedures should be made available to each employee who is exposed to cadmium dust at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the respiratory system, liver, kidneys, prostate, and blood should be stressed.

—Urinalysis: Since kidney damage has been observed in humans exposed to cadmium, a urinalysis should be obtained to include, at a minimum, specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. In addition, the urine should be examined for low molecular weight proteins by use of 3% sulfosalicylic or other acceptable techniques.

—14" x 17" chest roentgenogram: Cadmium causes human lung damage. Surveillance of the lungs is indicated.

—Liver function tests: Cadmium may cause liver damage. A profile of liver function should be obtained by utilizing a medically acceptable array of biochemical tests.

—FVC and FEV (1 sec): Cadmium is reported to cause decreased pulmonary function. Periodic surveillance is indicated.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis, except that an x-ray is considered necessary only when indicated by the results of pulmonary function testing, or by signs and symptoms of respiratory disease. Urine protein measurements should be made available every four months.

• **Summary of toxicology**

Cadmium dust causes both acute and chronic effects. It is less toxic than cadmium fume, because dust has a larger particle size than fume; at high concentrations of the dust, physiologic effects similar to those arising from fume exposure could be expected. The acute effects primarily involve the lungs but may also affect other organ systems. Most acute intoxications have been caused by inhalation of cadmium fume at concentrations which did not provide warning symptoms of irritation. The average concentrations of fume responsible for fatalities have been 40 to 50 mg/m³ for 1 hour, or 9 mg/m³ for 5 hours. Non-fatal pneumonitis has been reported from concentrations of 0.5 to 2.5 mg/m³, while relatively mild cases have been attributed to even lower concentrations. Following an asymptomatic latent period of 4 to 10 hours, there is characteristical nasopharyngeal irritation followed by a feeling of chest constriction or substernal pain, with persistent cough and dyspnea; there may also be headache, chills, muscle aches, nausea, vomiting, and diarrhea. Pulmonary edema may then develop and progress rapidly, with decreased vital capacity and markedly reduced carbon monoxide diffusing capacity. Cyanosis may be intense. In about 20% of the cases the dyspnea is progressive, accompanied by wheezing or hemoptysis, and may result in death within 7 to 10 days after exposure; at autopsy the lungs are markedly congested, and there is an intra-alveolar fibrinous exudate, as well as alveolar cell metaplasia. Among survivors, the subsequent course is unpredictable: most cases resolve slowly, but respiratory symptoms may linger for several weeks, while impairment of pulmonary function may persist for months. In experimental animals, cadmium exposure has caused pulmonary fibrosis, but this has not been documented in humans. In one fatal human case, in addition to lung abnormalities, there was renal cortical necrosis. Absorbed cadmium is retained to a large extent by the body, and excretion is very slow. Continued exposure to low levels of cadmium in air has resulted in chronic poisoning characterized by irreversible lung injury of an emphysematous type, with abnormal lung function and urinary excretion of a specific low-molecular-weight protein which may be associated with renal dysfunction. Clinical evidence of the cumulative effects of cadmium may appear after exposure has terminated; the disease then tends to be progressive. The frequency of occurrence of proteinuria increases with length of exposure: those exposed to cadmium compounds for less than 2 years had no proteinuria, whereas most of those exposed for 12 years or more had proteinuria with little other evidence of renal damage. The urinary excretion of cadmium bears no known relationship to the severity or duration of exposure and is only a confirmation of absorption. Other consequences of cadmium exposure are rhinitis, occasional ulceration of the nasal septum, damage to the olfactory nerve, and anosmia. The long-term ingestion of water, beans, and rice contaminated with cadmium has been proposed as the probable cause of a crippling condition among Japanese women who have had multiple pregnancies; severe pain in the back and joints, a waddly gait, osteomalacia, spontaneous fractures, and occasional fatal renal failure are characteristics of the disorder, which has been termed "itai-itai." Subcutaneous injection of cadmium metal suspended in fowl serum produced rhabdomyosarcomata in rats; cadmium sulfate in sterile distilled water produced sarcomata; and cadmium chloride solution produced pleomorphic sarcomata at the injection site. Increased incidence of prostatic cancer has been reported following occupational exposure to cadmium. Cadmium sulfate injected into the lingual vein of female hamsters on day 8 of pregnancy caused a high incidence of resorption and malformed offspring; acute necrosis of rat testes follows large doses orally or parenterally, but testicular effects have not been reported in humans.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data—Cadmium metal dust**

1. Molecular weight: 112.4
2. Boiling point (760 mm Hg): 767 C (1412 F)
3. Specific gravity (water = 1): 8.642
4. Vapor density (air = 1 at boiling point of cadmium metal dust): Not applicable
5. Melting point: 321 C (609 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Physical data—Cadmium oxide dust**

1. Molecular weight: 128.4
2. Boiling point (760 mm Hg): 900 C (1652 F) (sublimes and decomposes)
3. Specific gravity (water = 1): 6.95 or 8.15
4. Vapor density (air = 1 at boiling point of cadmium oxide dust): Not applicable
5. Melting point: 900 C (1652 F) (sublimes and decomposes)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 0.0005
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Physical data—Cadmium sulfide dust**

1. Molecular weight: 144.5
2. Boiling point (760 mm Hg): Sublimes in N_2 at 980 C (1796 F)
3. Specific gravity (water = 1): 4.82
4. Vapor density (air = 1 at boiling point of cadmium sulfide dust): Not applicable
5. Melting point: 1750 C (3182 F) at 100 atm.
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 0.0001
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Physical data—Cadmium chloride dust**

1. Molecular weight: 183
2. Boiling point (760 mm Hg): 960 C (1760 F)
3. Specific gravity (water = 1): 4.047
4. Vapor density (air = 1 at boiling point of cadmium chloride dust): Not applicable
5. Melting point: 568 C (1054 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 140
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Reactivity**

1. Conditions contributing to instability: None hazardous
2. Incompatibilities: Contact of cadmium metal dust with strong oxidizers or with elemental sulfur, selenium, and tellurium may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as cadmium oxide fume) may be released in a fire involving cadmium dust.
4. Special precautions: None

- **Flammability**

1. Flash point: Not applicable
2. Autoignition temperature: 250 C (482 F) (layer) (cadmium metal dust)
3. Minimum explosive dust concentration: Data not available
4. Extinguishant: Dry powder for metal fires

- **Warning properties**

Grant states that "cadmium is a very toxic metal which gives off fumes when burned or heated strongly. Characteristically these fumes cause dryness and irritation of the throat, followed in a few hours by nausea and diarrhea. Smarting of the eyes occurs relatively infrequently, and no injury to the eyes of human beings has been reported. Neither eye nor respiratory irritation is enough to prevent exposures which may cause serious systemic poisoning and damage to the lungs."

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of cadmium dust. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

Sampling and analyses may be performed by collection of cadmium dust on a filter, followed by treatment with nitric acid, solution in hydrochloric acid, and atomic absorption spectrophotometric analysis. An analytical method for cadmium dust is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• If employees' clothing has had any possibility of being contaminated with cadmium dust, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing which has had any possibility of being contaminated with cadmium dust should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of cadmium dust from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the cadmium dust, the person performing the operation should be informed of cadmium dust's hazardous properties.

• Employees should be provided with and required to use dust-resistant safety goggles where there is any possibility of cadmium chloride dust contacting the eyes.

• Where there is any possibility that employees' eyes may be exposed to cadmium chloride dust, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

• Workers subject to skin contact with cadmium dust should wash with soap or mild detergent and water any areas of the body which may have contacted cadmium dust at the end of each work day.

• Eating and smoking should not be permitted in areas where cadmium dust is handled, processed, or stored.

• Employees who handle cadmium dust should wash their hands thoroughly with soap or mild detergent and water before eating or smoking.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to cadmium dust may occur and control methods which may be effective in each case:

Operation	Controls
Liberation from fabrication of cadmium-plated marine, aircraft, and motor vehicle equipment for corrosion-resistant coatings	Local exhaust ventilation; personal protective equipment
Liberation during processing of cadmium metal	Process enclosure; local exhaust ventilation; personal protective equipment
Liberation in synthesis of cadmium compounds	Process enclosure; local exhaust ventilation
Liberation in manufacture and fabrication of cadmium alloys; recovery from flue dusts during smelting of lead and zinc operations	Local exhaust ventilation; personal protective equipment
Liberation during manufacture of nuclear reactor rods	Process enclosure; local exhaust ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If cadmium dust gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If cadmium dust gets on the skin, wash the contaminated skin using soap or mild detergent and water. Be sure to wash the hands well before eating or smoking and at the close of work.

• **Breathing**

If a person breathes in large amounts of cadmium dust, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When cadmium dust or liquids containing cadmium dust have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the

person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of releases until cleanup has been completed.

• If cadmium dust is released in hazardous concentrations, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of release.
3. Collect released material in the most convenient and safe manner for reclamation or for disposal in sealed conainers in a secured sanitary landfill.

• Waste disposal method:

Cadmium dust may be disposed of in sealed containers in a secured sanitary landfill.

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* SPECIAL NOTE

The International Agency for Research on Cancer (IARC) has evaluated the data on these chemicals and has concluded that they cause cancer. See *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man*, Volume 2, 1973, and Volume 11, 1976.

RESPIRATORY PROTECTION FOR CADMIUM DUST (AS CADMIUM)

Condition	Minimum Respiratory Protection* Required Above 0.2 mg/m³
Dust Concentration	
1 mg/m³ or less	Any dust respirator, except single-use.
2 mg/m³ or less	Any dust respirator, except single-use or quarter-mask respirator. Any high efficiency particulate filter respirator. Any supplied-air respirator. Any self-contained breathing apparatus.
10 mg/m³ or less	A high efficiency particulate filter respirator with a full facepiece. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
40 mg/m³ or less	A powered air-purifying respirator with a high efficiency particulate filter. A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.
Greater than 40 mg/m³ or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any dust respirator, except single-use. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Carbon Tetrachloride*

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: CCl_4
- Synonyms: Tetrachloromethane
- Appearance and odor: Colorless liquid with an ether-like odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for carbon tetrachloride is 10 parts of carbon tetrachloride per million parts of air (ppm) averaged over an eight-hour work shift, with an acceptable ceiling concentration of 25 ppm and a maximum allowable peak of 200 ppm for up to 5 minutes in any four-hour period. NIOSH has recommended that the permissible exposure limit be reduced to a ceiling level of 2 ppm averaged over a one-hour period, and that carbon tetrachloride be regulated as an occupational carcinogen. The NIOSH Criteria Document for Carbon Tetrachloride should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Carbon tetrachloride can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may be absorbed through the skin.

- **Effects of overexposure**

1. Short-term Exposure: Exposure to carbon tetrachloride may cause drowsiness, dizziness, incoordination, and unconsciousness. Delayed effects from short-term overexposure include damage to the heart, liver, and kidneys. Symptoms of liver damage include yellow jaundice and dark urine. Eye contact with liquid carbon tetrachloride causes burning and intense irritation.

2. Long-term Exposure: Prolonged or repeated exposure may cause liver and kidney damage. Repeated or prolonged contact of the liquid with the skin may cause skin irritation.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to carbon tetrachloride.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to carbon tetrachloride at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of liver and kidneys should be stressed. The skin and eyes should be examined for evidence of chronic disorders.

—Liver function tests: Carbon tetrachloride causes liver damage. A profile of liver function should be obtained using a medically acceptable array of biochemical tests.

—Urinalysis: Since kidney damage has also been observed from exposure, a urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

Carbon tetrachloride vapor is a narcotic and causes severe damage to the liver and kidneys. In animals the primary damage from intoxication is to the liver, but in humans the majority of fatalities have been the result of renal injury with secondary cardiac failure. In humans, liver damage occurs more often after ingestion of the

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These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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liquid than after inhalation of the vapor. Human fatalities from acute renal damage have occurred after exposure for @1/2 to 1 hour to concentrations of 1000 to 2000 ppm. Cardiac arrhythmias have been reported. Exposure to high concentrations results in symptoms of central nervous system depression, including dizziness, vertigo, incoordination, and mental confusion; abdominal pain, nausea, vomiting, and diarrhea are frequent. Polycythemia followed by anemia and hemodilution may occur. Within a few days, jaundice may appear and liver injury progress to toxic necrosis. At the same time, acute nephritis occurs, and albumin, red and white blood cells, and casts appear in the urine; there may be oliguria, anuria, and increased nitrogen retention resulting in the development of uremia. There are several reports of adverse effects in workmen who were repeatedly exposed to concentrations between 25 and 30 ppm; nausea, vomiting, dizziness, drowsiness, and headache were frequently noted. The effects of carbon tetrachloride in humans who are addicted to alcohol are more severe than usual. No adverse symptoms resulted from repeated exposure to 10 ppm. The liquid splashed in the eye causes pain and minimal injury to the conjunctiva. Prolonged or repeated skin contact with the liquid may result in skin irritation. It can be absorbed through the intact skin of animals and humans in toxic amounts. Hepatomas have been reported in several animal species and in man.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 153.8
  2. Boiling point (760 mm Hg): 76.8 C (170 F)
  3. Specific gravity (water = 1): 1.59
  4. Vapor density (air = 1 at boiling point of carbon tetrachloride): 5.3
  5. Melting point: −23 C (-9 F)
  6. Vapor pressure at 20 C (68 F): 91 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): 0.08
  8. Evaporation rate (butyl acetate = 1): 12.8
- **Reactivity**
  1. Conditions contributing to instability: None
  2. Incompatibilities: Carbon tetrachloride reacts with chemically active metals such as sodium, potassium, and magnesium.
  3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, chlorine, phosgene, and carbon monoxide) may be released when carbon tetrachloride decomposes.
  4. Special precautions: Liquid carbon tetrachloride will attack some forms of plastics, rubber, and coatings.
- **Flammability**
  1. Not combustible
- **Warning properties**
  1. Odor Threshold: Carbon tetrachloride has an odor threshold of approximately 50 ppm, according to the *Hygienic Guide.*
  2. Eye Irritation Level: Grant states that carbon tetrachloride is slightly irritating to the eyes, but does not mention the concentrations at which irritation occurs. In addition, carbon tetrachloride is "strongly suspected of causing retrobulbar neuritis, optic neuritis, and optic atrophy."
  3. Evaluation of Warning Properties: Since the odor threshold of carbon tetrachloride is well above the permissible exposure, and since no quantitative data are available relating its warning properties to air concentrations, carbon tetrachloride is considered as a substance with poor warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of carbon tetrachloride. Each measurement to determine short-duration ceiling levels should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure. Each measurement to determine a one-hour ceiling should consist of a one-hour sample or a series of consecutive samples totalling one hour.

- **Peak Above Ceiling Evaluation**

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of carbon tetrachloride. Each measurement should consist of a 30-minute sample or a series of consecutive samples totalling 30 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure carbon tetrachloride may be used. An analytical method for carbon tetrachloride is in the

NIOSH Manual of Analytical Methods, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid carbon tetrachloride.
- Clothing wet with liquid carbon tetrachloride should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of carbon tetrachloride from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the carbon tetrachloride, the person performing the operation should be informed of carbon tetrachloride's hazardous properties.
- Non-impervious clothing which becomes contaminated with liquid carbon tetrachloride should be removed promptly and not reworn until the carbon tetrachloride is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid carbon tetrachloride may contact the eyes.

SANITATION

- Skin that becomes wet with liquid carbon tetrachloride should be promptly washed or showered with soap or mild detergent and water to remove any carbon tetrachloride.
- Eating and smoking should not be permitted in areas where carbon tetrachloride is handled, processed, or stored.
- Employees who handle liquid carbon tetrachloride should wash their hands thoroughly with soap or mild detergent and water before eating or smoking.
- Areas in which exposure to carbon tetrachloride can occur should be identified by signs or other appropriate means, and access to these areas should be limited to authorized persons.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to carbon tetrachloride may occur and control methods which may be effective in each case:

Operation	Controls
Use in manufacture of fluorocarbons for aerosols, refrigerants, and fire extinguishants	Material substitution; process enclosure; local exhaust ventilation; personal protective equipment
Use as an agricultural grain fumigant and pesticide	Material substitution; personal protective equipment
Use in polymer technology as reaction medium, catalyst, chain transfer agent, and solvent for resins; in organic synthesis for chlorination of organic compounds in soap perfumery and insecticide industries	Process enclosure; local exhaust ventilation
Use as an industrial solvent for rubber cements, cable and semiconductor manufacture, separation of xylene isomers as components to reduce flammability	Material substitution; process enclosure; local exhaust ventilation; personal protective equipment
Use as a laboratory solvent	Material substitution; personal protective equipment
Use in metal recovery and catalyst regeneration	Process enclsoure; local exhaust ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If carbon tetrachloride gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present

after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If carbon tetrachloride gets on the skin, immediately wash the contaminated skin using soap or mild detergent and water. If carbon tetrachloride soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of carbon tetrachloride, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When carbon tetrachloride has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If carbon tetrachloride is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. Collect for reclamation or absorb in vermiculite, dry sand, earth, or a similar material.

• Waste disposal method:

Carbon tetrachloride may be disposed of by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.

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* SPECIAL NOTE

The International Agency for Research on Cancer (IARC) has evaluated the data on this chemical and has concluded that it causes cancer. See *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man*, Volume 1, 1972.

RESPIRATORY PROTECTION FOR CARBON TETRACHLORIDE

Condition	Minimum Respiratory Protection* Required Above 10 ppm
Vapor Concentration	
100 ppm or less	Any supplied-air respirator. Any self-contained breathing apparatus.
300 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 300 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Chloroform*

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $CHCl_3$
- Synonyms: Trichloromethane
- Appearance and odor: Colorless liquid with a pleasant, sweet odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for chloroform is a ceiling level of 50 parts of chloroform per million parts of air (ppm). This may also be expressed as 240 milligrams of chloroform per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be reduced to a ceiling level of 2 ppm averaged over a one-hour period, and that chloroform be regulated as an occupational carcinogen. The NIOSH Criteria Document for Chloroform should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Chloroform can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- **Effects of overexposure**

1. Short-term Exposure: Chloroform vapor may cause headache, drowsiness, vomiting, dizziness, unconsciousness, irregular heart beat, and death. Liver and kidney damage may also result from exposure to chloroform vapor. When splashed in the eye, chloroform causes pain and irritation. Swallowing chloroform is followed immediately by severe burning of the mouth and throat, pain in the chest and abdomen, and vomiting. Depending on the amount swallowed, loss of consciousness and liver damage may follow.

2. Long-term Exposure: Prolonged exposure to chloroform may cause liver and kidney damage. Prolonged or repeated skin contact with the liquid may produce skin irritation.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to chloroform.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to chloroform at potentially hazardous levels:

1. Initial Medical Examination:

— A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. A history of, or physical signs consistent with, chronic alcoholism probably constitutes such an increased risk. Examination of liver, kidneys, and heart should be stressed. The skin should be examined for evidence of chronic disorders.

— Liver function tests: A profile of liver function should be obtained by using a medically acceptable array of biochemical tests.

— Urinalysis: Since kidney damage has also been observed from exposure, a urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

Chloroform vapor is a central nervous system depressant and is toxic to the liver and kidneys. It has been largely abandoned as an anesthetic agent because of the frequency of cardiac arrest during surgery and of

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These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

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delayed death due to hepatic injury. An increased incidence of cardiac arrhythmias has been demonstrated during surgery in patients anesthetized with chloroform, as compared with other anesthetic agents; vapor concentrations were of the order of 22,500 ppm. Animals showed minor and reversible injury of liver and kidneys after repeated 7-hour exposures to concentrations of chloroform as low as 25 ppm, while 50 to 85 ppm produced more severe injury. Experimental human exposures showed that 14,000 to 16,000 ppm caused rapid loss of consciousness in man; 4100 ppm or less caused serious disorientation, while single exposures of 1000 ppm caused dizziness, nausea, and aftereffects of fatigue and headache. Prolonged exposure to 80 to 240 ppm caused lassitude, digestive disturbances, and mental dullness, while 20 to 70 ppm produced milder symptoms. Of 68 chemical workers exposed regularly to concentrations of 2 to 205 ppm for 1 to 4 years, some 25% had hepatomegaly. This group of 68 exposed workers were found to be more susceptible to viral hepatitis than the general population. The hepatotoxicity of several chlorinated hydrocarbons has been shown to be potentiated by prior exposure to some aliphatic alcohols. This phenomenon has been demonstrated in mice exposed first to isopropyl alcohol by gavage and then to chloroform by intraperitoneal injection. A potentiating effect of ethyl alcohol ingestion on the toxicity of chloroform vapor in the occupational setting is suspected, but has not been proven in industrial practice. High concentrations of vapor cause conjunctival irritation and blepharospasm. Liquid chloroform splashed in the eye causes immediate burning pain and conjunctival irritation; the corneal epithelium may be injured, but regeneration is prompt, and the eye returns to normal in 1 to 3 days. The liquid has a defatting effect on the skin and may produce chronic irritation with drying and cracking. Liver tumors have been reported in animals.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 119.4
2. Boiling point (760 mm Hg): 61 C (142 F)
3. Specific gravity (water = 1): 1.49
4. Vapor density (air = 1 at boiling point of chloroform): 4.1
5. Melting point: −63.5 C (−82 F)
6. Vapor pressure at 20 C (68 F): 160 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 0.8
8. Evaporation rate (butyl acetate = 1): 11.6

- **Reactivity**

1. Conditions contributing to instability: In the presence of air and light, chloroform slowly reacts to form toxic phosgene and hydrogen chloride gases.
2. Incompatibilities: Chloroform reacts with strong caustics and chemically active metals such as aluminum, magnesium powder, sodium, or potassium.
3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, chlorine, phosgene, and carbon monoxide) may be released when chloroform decomposes.
4. Special precautions: Liquid chloroform will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Not combustible

- **Warning properties**

1. Odor Threshold: Patty reports that the odor threshold of chloroform is approximately 200 to 300 ppm, and May reports an odor threshold of 200 ppm. The *Hygienic Guide*, however, gives an odor threshold of 50 ppm and states that "olfactory fatigue" occurs upon exposure.
2. Eye Irritation Level: Grant states that "in conscious individuals high concentrations of vapors of chloroform cause moderate sensation of stinging and irritation of the eyes, automatically inducing protective closure of the lids." The concentrations causing eye irritation are not mentioned. However, Patty does not give any indication that eye irritation occurs at concentrations even as high as 4096 ppm.
3. Evaluation of Warning Properties: Since there are no quantitative data relating the irritant effects of chloroform to air concentrations, and since olfactory fatigue occurs during exposure to chloroform, this material is treated as a substance with poor warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **One-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average one-hour exposure is based on a single one-hour sample. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of chloroform. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure chloroform may be used. An

analytical method for chloroform is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with liquid chloroform, where skin contact may occur.
- Clothing wet with liquid chloroform should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of chloroform from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the chloroform, the person performing the operation should be informed of chloroform's hazardous properties.
- Non-impervious clothing which becomes wet with liquid chloroform should be removed promptly and not reworn until the chloroform is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid chloroform may contact the eyes.
- Where there is any possibility that employees' eyes may be exposed to chloroform, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes wet with liquid chloroform should be promptly washed or showered with soap or mild detergent and water to remove any chloroform.
- Eating and smoking should not be permitted in areas where liquid chloroform is handled, processed, or stored.
- Employees who handle liquid chloroform should wash their hands thoroughly with soap or mild detergent and water before eating or smoking.
- Areas in which exposure to chloroform may occur should be identified by signs or other appropriate means, and access to these areas should be limited to authorized persons.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to chloroform may occur and control methods which may be effective in each case:

Operation	Controls
Use in manufacture of fluorocarbons for refrigerant propellants; manufacture of fluorocarbon resins	Process enclosure; local exhaust ventilation; general dilution ventilation
Use as an extractant solvent in manufacure of pharmaceuticals, rubber, essential oils and flavors, sterols and alkaloids, and in the recovery of fat from waste products	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in chemical analysis and assays; veterinary uses, and in standard solutions as preservative and bactericide	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as a general solvent in plastics, dyes, oils, waxes, rubber, cleaning and dry cleaning industries	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as a chemical intermediate in dye, drug, and pesticide industries	Process enclosure; local exhaust ventilation; general dilution ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If chloroform gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If burning is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If chloroform gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If chloroform soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of chloroform, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When chloroform has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND LEAK PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If chloroform is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. Collect for reclamation or absorb in vermiculite, dry sand, earth, or a similar material.

ADDITIONAL INFORMATION

To find additional information on chloroform, look up chloroform in the following documents:

• Medical Surveillance for Chemical Hazards

• Respiratory Protection for Chemical Hazards

• Personal Protection and Sanitation for Chemical Hazards

• NIOSH Criteria Document for Chloroform (Revised June 1976)

These documents are available through the NIOSH Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

REFERENCES

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• Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

• Traiger, G. J., and Plaa, G. L.: "Chlorinated Hydrocarbon Toxicity," *Archives of Environmental Health*, 28:276-278, 1974.

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* SPECIAL NOTE

The International Agency for Research on Cancer (IARC) has evaluated the data on this chemical and has concluded that it causes cancer. See *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man*, Volume 1, 1972.

RESPIRATORY PROTECTION FOR CHLOROFORM

Condition	Minimum Respiratory Protection* Required Above 50 ppm
Vapor Concentration	
500 ppm or less	Any supplied-air respirator. Any self-contained breathing apparatus.
1000 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 1000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Chromium Metal and Insoluble Chromium Salts*

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

APPLICABILITY

The general guidelines contained in this document apply to all chromium metal and insoluble chromium salts. Physical and chemical properties of some specific compounds are provided for illustrative purposes.

SUBSTANCE IDENTIFICATION

Metallic chromium

- Formula: Cr
- Synonyms: None
- Appearance and odor: Shiny, odorless metal.

Copper chromite

- Formula: $Cu_2Cr_2O_4$
- Synonyms: Cuprous chromite
- Appearance and odor: Greenish-blue, odorless solid.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for chromium metal or insoluble chromium salts is 1 milligram of chromium metal or insoluble chromium salts per cubic meter of air (mg/m^3) averaged over an eight-hour work shift. Certain forms of chromium (VI) have been found to cause increased respiratory cancer among workers. Certain other forms of chromium (VI) are currently believed to be non-carcinogenic: The non-carcinogenic forms are the monochromates and bichromates (dichromates) of hydrogen, lithium, sodium, potassium, rubidium, cesium, and ammonium, and chromium (VI) oxide (chromium acid anhydride). NIOSH has not conducted an in-depth study of the toxicity of chromium metal or compounds containing chromium in an oxidation state other than 6. NIOSH recommends that the permissible exposure limit for carcinogenic chromium (VI) compounds be reduced to 0.001 Cr (VI) mg/m^3 and that these compounds be regulated as occupational carcinogens. NIOSH also recommends that the permissible exposure limit for non-carcinogenic chromium (VI) be reduced to 0.025 Cr (VI) mg/m^3 averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling level of 0.05 Cr (VI) mg/m^3 averaged over a 15-minute period. It is further recommended that chromium (VI) in the workplace be considered carcinogenic, unless it has been demonstrated that only the non-carcinogenic chromium (VI) compounds mentioned above are present. The NIOSH Criteria Documents for Chromic Acid and Chromium (VI) should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Chromium metal or insoluble chromium salts can affect the body if they are inhaled. They can also affect the body if they are swallowed.

- **Effects of overexposure**

Ferro chrome alloys have been associated with lung changes in workers exposed to these alloys. Chromite dust exposure may cause minor lung changes.

- **Reporting signs and symptoms**

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to chromium metal or insoluble chromium salts.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to chromium metal or insoluble chromium salts at potentially hazardous levels:

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the respiratory system should be stressed.

—14" x 17" chest roentgenogram: Chromium and its insoluble salts may cause human lung damage. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Insoluble chromium salts are reported to cause decreased pulmonary function. Periodic surveillance is indicated.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• **Summary of toxicology**

The dusts of chromium metal and its insoluble salts, chiefly the chromites, are usually reported to be relatively nontoxic; this is debatable, since exposures associated with toxic effects are usually mixed exposures involving several hexavalent chromium compounds. Ferrochrome alloys have been associated with pulmonary disease in humans. Four workers engaged in the production of ferrochrome alloys developed a nodular type of pulmonary disease with impairment of pulmonary function; air concentrations of chromium in this study averaged 0.26 mg/m^3, although other fumes and dusts were also present. This pulmonary problem may be one of hypersensitivity and thus reversible. Other reports state that chest roentgenograms have revealed only "exaggerated pulmonic markings" in workers exposed to chromite dust. The lungs of groups of workers exposed to chromite dust have been shown to be the seat of pneumoconiotic changes consisting of slight thickening of interstitial tissue and interalveolar septa, with histologic fibrosis and hyalinization. Chromite ore roast mixed with sheep fat implanted intrapleurally in rats produced squamous cell carcinomata coexisting with sarcomata of the lungs; the same material implanted in the thighs of rats produced fibrosarcomata. A refractory plant using chromite ore to make chromite brick had no excess of lung cancer deaths over a 14-year period, and it was concluded that chromite alone probably is not carcinogenic.

CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data—Metallic chromium**

1. Molecular weight: 52
2. Boiling point (760 mm Hg): 2640 C (4784 F)
3. Specific gravity (water = 1): 7.2
4. Vapor density (air = 1 at boiling point of metallic chromium): Not applicable
5. Melting point: 1900 C (3452 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Copper chromite**

1. Molecular weight: 295.1
2. Boiling point (760 mm Hg): Data not available
3. Specific gravity (water = 1): 5.24
4. Vapor density (air = 1 at boiling point of copper chromite): Not applicable
5. Melting point: Data not available
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Basic potassium zinc chromate**

1. Molecular weight: 873.8
2. Boiling point (760 mm Hg): Decomposes at red heat
3. Specific gravity (water = 1): 3.47
4. Vapor density (air = 1 at boiling point of basic potassium zinc chromate): Not applicable
5. Melting point: Loses water slowly above 100 C (212 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Reactivity**

1. Conditions contributing to instability: None
2. Incompatibilities: Chromium metal in contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: None listed.
4. Special precautions: None listed.

• **Flammability**

1. Flash point: Not applicable
2. Minimum ignition temperature (metal): 400 C (752 F) (layer); 580 C (1076 F) (cloud)
3. Minimum explosive dust concentration (metal): 230 grams/m^3
4. Extinguishant: Dry sand, dry dolomite, dry graphite

• **Warning properties**

Chromium metal and insoluble salts are not known to be eye irritants.

MONITORING AND MEASUREMENT PROCEDURES

• **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected

airborne concentrations of chromium metal or insoluble chromium salts. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of chromium metal or insoluble chromium salts on a filter, followed by treatment with acid and atomic absorption spectrophotometric analysis. An analytical method for chromium metal and insoluble chromium salts is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 6, 1980, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00369-6).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with solids or liquids containing insoluble chromium salts.

• Clothing contaminated with insoluble chromium salts should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of insoluble chromium salts from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the insoluble chromium salts, the person performing the operation should be informed of insoluble chromium salts's hazardous properties.

• Non-impervious clothing which becomes contaminated with insoluble chromium salts should be removed promptly and not reworn until the insoluble chromium salts are removed from the clothing.

• Employees should be provided with and required to use dust- and splashproof safety goggles where solids or liquids containing insoluble chromium salts may contact the eyes.

SANITATION

• Skin that becomes contaminated with insoluble chromium salts should be promptly washed or showered with soap or mild detergent and water to remove any insoluble chromium salts.

• Eating and smoking should not be permitted in areas where solids or liquids containing insoluble chromium salts are handled, processed, or stored.

• Employees who handle solids or liquids containing insoluble chromium salts should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to chromium metal or insoluble chromium salts may occur and control methods which may be effective in each case:

Operation	Controls
Use in fabrication of alloys	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in preparation of alloy steels to enhance corrosion- and heat-resistance	Local exhaust ventilation; general dilution ventilation
Use in fabrication of plated products for decoration or increased wear-resistance	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in production of non-ferrous alloys to impart special qualities to the alloys	Local exhaust ventilation; general dilution ventilation
Use in production and processing of insoluble salts	Local exhaust ventilation; general dilution ventilation; personal protective equipment

Operation	Controls
Use as chemical intermediates; use in textile industry in dyeing, silk treating, printing, and moth-proofing wool	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in leather industry in tanning; use in photograhic fixing baths	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as catalysts for halogenation, alkylation, and catalytic cracking of hydrocarbons	Local exhaust ventilation; general dilution ventilation
Use as fuel additives and propellant additives; in photogaphic fixing baths and in ceramics	Local exhaust ventilation; general dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If chromium metal or solids or liquids containing insoluble chromium salts get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with these chemicals.

• **Skin Exposure**

If solids or liquids containing insoluble chromium salts get on the skin, wash the contaminated skin using soap or mild detergent and water. If solids or liquids containing insoluble chromium salts penetrate through the clothing, remove the clothing and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of chromium metal or insoluble chromium salts, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When solids or liquids containing insoluble chromium salts have been swallowed, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills until cleanup has been completed.

• If chromium metal or insoluble chromium salts are spilled, the following steps should be taken:

1. Remove all ignition sources where metallic chromium has been spilled.
2. Ventilate area of spill.
3. Collect spilled material in the most convenient and safe manner and deposit in sealed containers for reclamation or for disposal in a secured sanitary landfill. Liquid containing chromium metal or insoluble chromium salts should be absorbed in vermiculite, dry sand, earth, or a similar material.

• Waste disposal method:

Chromium metal or insoluble chromium salts may be disposed of in sealed containers in a secured sanitary landfill.

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* SPECIAL NOTE

The International Agency for Research on Cancer (IARC) has evaluated the data on these chemicals and has concluded that they cause cancer. See *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man*, Volume 2, 1973, and Volume 23, 1980.

• **Method**

Sampling and analyses may be performed by collection of chromium metal or insoluble chromium salts on a filter, followed by treatment with acid and atomic

RESPIRATORY PROTECTION FOR CHROMIUM METAL AND INSOLUBLE CHROMIUM SALTS (AS CHROMIUM)

Condition	Minimum Respiratory Protection* Required Above 1 mg/m³
Particulate Concentration	
5 mg/m³ or less	Any dust and mist respirator.
10 mg/m³ or less	Any dust and mist respirator, except single-use or quarter-mask respirator. Any fume respirator or high efficiency particulate respirator. Any supplied-air respirator. Any self-contained breathing apparatus.
50 mg/m³ or less	A high efficiency particulate filter respirator with a full facepiece. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
500 mg/m³ or less	A powered air-purifying respirator with a high efficiency particulate filter. A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.
Greater than 500 mg/m³ or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

*Only NIOSH-approved or MSHA-approved equipment should be used.

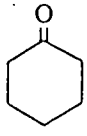
OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR CYCLOHEXANONE

INTRODUCTION

This guideline summarizes pertinent information about cyclohexanone for workers, employers, and occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

- **Formula:** $C_6H_{10}O$
- **Structure:**



- **Synonyms:** Anone, hexanon, ketohexamethylene, nadone, pimelic ketone, pimelin ketone
- **Identifiers:** CAS 108-94-1; RTECS GW1050000; DOT 1915, label required: "Flammable Liquid"
- **Appearance and odor:** Colorless to slightly yellow liquid with an odor like peppermint

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 98.16
2. Boiling point (at 760 mmHg): 155.6°C (312°F)
3. Specific gravity (water = 1): 0.95
4. Vapor density (air = 1 at boiling point of cyclohexanone): 3.4
5. Melting point: -47°C (-52.6°F)
6. Vapor pressure at 20°C (68°F): 2 mmHg; at 25°C (77°F), 4.5 mmHg
7. Slightly soluble in water
8. Evaporation rate (butyl acetate = 1): 0.23
9. Saturation concentration in air (approximate) at 20°C (68°F): 0.26% (2,600 ppm); at 25°C (77°F), 0.60% (6,000 ppm)
10. Ionization potential: 9.14 eV

- **Reactivity**

1. Incompatibilities: Cyclohexanone may react with oxidizing agents and nitric acid causing fires and explosions.
2. Hazardous decomposition products: Toxic vapors and gases (e.g., carbon monoxide) may be released in a fire involving cyclohexanone.
3. Caution: Cyclohexanone will dissolve most plastics, resins, and rubber.

- **Flammability**

1. Flash point: 43.9°C (111°F) (closed cup)
2. Autoignition temperature: 420°C (788°F)
3. Flammable limits in air, % by volume: Lower, 1.1; Upper, 9.4
4. Extinguishant: Alcohol foam, dry chemical, or carbon dioxide
5. Class II Combustible Liquid (29 CFR 1910.106), Flammability Rating 2 (NFPA)

- **Warning properties**

1. Odor threshold: 0.88 ppm
2. Eye irritation level: 75 ppm
3. Evaluation of warning properties for respirator selection: Because of its odor, cyclohexanone can be detected at concentrations below the National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL); thus, it is treated as a chemical with adequate warning properties.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for cyclohexanone is 50 parts of cyclohexanone per million parts of air (ppm) [200 milligrams of cyclohexanone per cubic meter of air (mg/m³)] as a time-weighted average (TWA) concentration over an 8-hour workshift. The NIOSH REL is 25 ppm (100 mg/m³) as a TWA for up to a 10-hour workshift, 40-hour workweek. The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV®) is 25 ppm (100 mg/m³) (Skin) as a TWA for a normal 8-hour workday and a 40-hour workweek (Table 1).

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Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

Table 1.—Occupational exposure limits for cyclohexanone

	Exposure limits ppm	mg/m³
OSHA PEL TWA	50	200
NIOSH REL TWA	25	100
ACGIH TLV® TWA (Skin)	25	100

HEALTH HAZARD INFORMATION

• **Routes of exposure**

Cyclohexanone may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.

• **Summary of toxicology**

Effects on animals: Subchronic inhalation of cyclohexanone by rabbits and monkeys caused central nervous system depression and liver and kidney degeneration. Cutaneous or subcutaneous application of cyclohexanone for several days caused cataracts in guinea pigs.

• **Signs and symptoms of exposure**

1. *Short-term (acute):* Exposure to cyclohexanone can cause dizziness and unconsciousness. Irritation of the eyes, nose, and throat can also occur.
2. *Long-term (chronic):* Dermal exposure to cyclohexanone can cause dryness, irritation, and inflammation of the skin.

RECOMMENDED MEDICAL PRACTICES

• **Medical surveillance program**

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, morbidity, and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• **Preplacement medical evaluation**

Prior to placing a worker in a job with a potential for exposure to cyclohexanone, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the eyes, skin, liver, kidneys, and respiratory system. Medical surveillance for respiratory disease should be conducted by using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to cyclohexanone at or below the NIOSH REL. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindication to job placement, include concurrent dermatitis or a history of chronic skin disease.

• **Periodic medical screening and/or biologic monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to cyclohexanone. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the physiologic function of the eyes, skin, liver, kidneys, and nervous and respiratory systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population. The following tests should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH and the ATS: standardized questionnaires and tests of lung function.

• **Medical practices recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population.

• **Sentinel health events**

Acute SHE's include: Contact and/or allergic dermatitis.

MONITORING AND MEASUREMENT PROCEDURES

• **TWA exposure evaluation**

Measurements to determine worker exposure to cyclohexanone should be taken so that the TWA exposure is based on a single entire workshift sample or an appropriate number of consecutive samples collected during the entire workshift. Under cer-

tain conditions, it may be appropriate to collect several short-term interval samples (up to 30 minutes each) to determine the average exposure level. Air samples should be taken in the worker's breathing zone (air that most nearly represents that inhaled by the worker).

• **Method**

Sampling and analysis may be performed by collecting cyclohexanone vapors with charcoal tubes followed by desorption with carbon disulfide and analysis by gas chromatography. Detector tubes or other direct-reading devices calibrated to measure cyclohexanone may also be used if available. A detailed sampling and analytical method for cyclohexanone may be found in the *NIOSH Manual of Analytical Methods* (method number 1300).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, face shields (8-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with cyclohexanone.

Workers should be provided with and required to use splash-proof safety goggles where cyclohexanone may come in contact with the eyes.

SANITATION

Clothing which is contaminated with cyclohexanone should be removed immediately and placed in closed containers for storage until it can be discarded or until provision is made for the removal of cyclohexanone from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of cyclohexanone's hazardous properties.

Change and shower rooms should be provided with separate locker facilities for street and work clothes.

Skin that becomes contaminated with cyclohexanone should be promptly washed with soap and water.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or application of cosmetics, the storage or smoking of tobacco or other smoking materials, or the storage or use of products for chewing should be prohibited in work areas.

Workers who handle cyclohexanone should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to cyclohexanone may occur and control methods which may be effective in each case are listed in Table 2.

Table 2.—Operations and methods of control for cyclohexanone

Operations	Controls
During surface coating or spray painting of fabrics and plastics	Local exhaust ventilation, personal protective equipment
During cleaning of leathers and textiles; during degreasing of leathers and metals	Local exhaust ventilation, personal protective equipment
During use as a solvent in crude rubber, insecticides, and epoxy resins; during use as a sludge solvent in lubricating oils	Local exhaust ventilation, personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures.

• **Eye exposure**

Where there is any possibility of a worker's eyes being exposed to cyclohexanone, an eye-wash fountain should be provided within the immediate work area for emergency use.

If cyclohexanone gets into the eyes, flush them immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• **Skin exposure**

Where there is any possibility of a worker's body being exposed to cyclohexanone, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If cyclohexanone gets on the skin, wash it immediately with soap and water. If cyclohexanone penetrates the clothing, remove the clothing immediately and wash the skin with soap and water. Get medical attention promptly.

• **Rescue**

If a worker has been incapacitated, move the affected worker from the hazardous exposure. Put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILLS AND LEAKS

Workers not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

If cyclohexanone is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities of liquids containing cyclohexanone, absorb on paper towels and place in an appropriate container. Place towels in a safe place (such as a fume hood) for evaporation. Allow sufficient time for evaporation of the vapors so that the hood ductwork is free from cyclohexanone vapors. Burn the paper in a suitable location away from combustible materials.
4. Large quantities of liquids containing cyclohexanone may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container. Cyclohexanone should not be allowed to enter a confined space such as a sewer because of the possibility of an explosion.
5. Cyclohexanone may be collected by vacuuming with an appropriate system. If a vacuum system is used, there should be no sources of ignition in the vicinity of the spill and flashback prevention devices should be provided.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards, 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

For each level of respiratory protection, only those respirators that have the minimum required protection factor and meet other use restrictions are listed. All respirators that have higher protection factors may also be used.

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Table 3.—Respiratory protection for cyclohexanone

Condition	Minimum respiratory protection*†
Concentration:	
Less than or equal to 625 ppm	Any supplied-air respirator operated in a continuous flow mode (substance causes eye irritation or damage—eye protection needed)
	Any powered air-purifying respirator with organic vapor cartridge(s) (substance causes eye irritation or damage—eye protection needed)
Less than or equal to 1,000 ppm	Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s)
Less than or equal to 1,250 ppm	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister
	Any self-contained breathing apparatus with a full facepiece
	Any supplied-air respirator with a full facepiece
Less than or equal to 5,000 ppm	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown concentrations or levels above 5,000 ppm	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister
	Any appropriate escape-type self-contained breathing apparatus

* Only NIOSH/MSHA-approved equipment should be used.
†The respiratory protection listed for any given condition is the minimum required to meet the NIOSH REL of 25 ppm (100 mg/m^3) (TWA).

Occupational Health Guideline for 1,1-Dichloroethane

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: CH_3CHCl_2
- Synonyms: Asymmetrical dichloroethane; ethylidene chloride; 1,1-ethylidene dichloride
- Appearance and odor: Colorless liquid with a chloroform-like odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for 1,1-dichloroethane is 100 parts of 1,1-dichloroethane per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 400 milligrams of 1,1-dichloroethane per cubic meter of air (mg/m^3). The American Conference of Governmental Industrial Hygienists has recommended for 1,1-dichloroethane a Threshold Limit Value of 200 ppm.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

1,1-Dichloroethane can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- **Effects of overexposure**

1. Short-term Exposure: Breathing 1,1-dichloroethane vapor may cause drowsiness and unconsciousness. It might also cause damage to the liver, kidneys, and lungs. Splashing the liquid in the eyes may cause irritation.

2. Long-term Exposure: Prolonged, confined, or repeated skin contact with 1,1-dichloroethane can produce a slight burn.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to 1,1-dichloroethane.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to 1,1-dichloroethane at potentially hazardous levels:

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from 1,1-dichloroethane exposure.

—Skin disease: 1,1-Dichloroethane can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver disease: Although 1,1-dichloroethane is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Kidney disease: Although 1,1-dichloroethane is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of 1,1-dichloroethane might cause exacerbation of symptoms due to its irritant properties.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

- **Summary of toxicology**

1,1-Dichloroethane vapor is a narcotic. Rats exposed to 32,000 ppm for 30 minutes did not survive. The most consistent findings in animals exposed to concentrations

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These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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of above 8,000 ppm for up to 7 hours were pathologic changes in the kidney and liver, and at much higher concentrations, near 64,000 ppm, damage to the lungs as well. Repeated daily exposure of several species of animals to 1,000 ppm resulted in no pathologic or hematologic changes. The liquid applied to the intact or abraded skin of rabbits produced slight edema and very slight necrosis after six daily applications. Instilled in the eyes of rabbits there was immediate, moderate conjunctival irritation and swelling which subsided within a week. There have been no reported cases of human overexposure by inhalation; prolonged, confined, or repeated skin contact can produce a slight burn.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 99
  2. Boiling point (760 mm Hg): 57.3 C (135 F)
  3. Specific gravity (water = 1): 1.2
  4. Vapor density (air = 1 at boiling point of 1,1-dichloroethane): 3.4
  5. Melting point: −96.7 C (−142 F)
  6. Vapor pressure at 20 C (68 F): 182 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): Less than 0.1
  8. Evaporation rate (butyl acetate = 1): 11.6
- **Reactivity**
  1. Conditions contributing to instability: Heat
  2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions. Contact with strong caustics will cause formation of flammable and toxic acetaldehyde gas.
  3. Hazardous decomposition products: Toxic gases and vapors (such as vinyl chloride, hydrogen chloride, phosgene, and carbon monoxide) may be released in a fire involving 1,1-dichloroethane.
  4. Special precautions: 1,1-Dichloroethane will attack some forms of plastics, rubber, and coatings.
- **Flammability**
  1. Flash point: −8.5 C (17 F) (closed cup)
  2. Autoignition temperature: Data not available
  3. Flammable limits in air, % by volume: Lower: 5.9; Upper: 15.9
  4. Extinguishant: Foam, dry chemical, carbon dioxide
- **Warning properties**

The AIHA *Hygienic Guide* reports that 1,1-dichloroethane has a distinctive, easily recognizable odor at the TLV.

1,1-Dichloroethane is not known to be an eye irritant.

MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure 1,1-dichloroethane may be used. An analytical method for 1,1-dichloroethane is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid 1,1-dichloroethane.
- Clothing wet with liquid 1,1-dichloroethane should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of 1,1-dichloroethane from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the 1,1-dichloroethane, the person performing the operation should be informed of 1,1-dichloroethane's hazardous properties.
- Any clothing which becomes wet with liquid 1,1-dichloroethane should be removed immediately and not

reworn until the 1,1-dichloroethane is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where liquid 1,1-dichloroethane may contact the eyes.

SANITATION

• Skin that becomes wet with liquid 1,1-dichloroethane should be immediately washed or showered with soap or mild detergent and water to remove any 1,1-dichloroethane.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to 1,1-dichloroethane may occur and control methods which may be effective in each case:

Operation	Controls
Use as dewaxer of mineral oils; extractant for heat-sensitive substances	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use as a fumigant	General dilution ventilation of work area; personal protective equipment
Use in manufacture of vinyl chloride by vapor phase cracking; use in manufacture of high vacuum rubber and silicon grease; use as a chemical intermediate	General dilution ventilation; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If 1,1-dichloroethane gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If 1,1-dichloroethane gets on the skin, promptly flush the contaminated skin using soap or mild detergent and water. If 1,1-dichloroethane soaks through the clothing, remove the clothing immediately and flush the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of 1,1-dichloroethane, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When 1,1-dichloroethane has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If 1,1-dichloroethane is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. 1,1-Dichloroethane should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of 1,1-dichloroethane vapors are permitted.

• Waste disposal method:

1,1-Dichloroethane may be disposed of by atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

REFERENCES

• American Conference of Governmental Industrial Hygienists: "1,1-Dichloroethane (Ethylidene Chloride)," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

• American Industrial Hygiene Association: "1,1-Dichloroethane (Ethylidene Chloride)," *Hygienic Guide Series*, Detroit, Michigan, 1971.

• Browning, E.: *Toxicity and Metabolism of Industrial Solvents*, Elsevier, New York, 1965.
• Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.
• Elkins, H. B.: *Chemistry of Industrial Toxicology* (2nd ed.), Wiley, New York, 1959.
• Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
• Kirk, R., and Othmer, D.: *Encyclopedia of Chemical Technology* (2nd ed.), Interscience, New York, 1968.
• Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.
• Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

RESPIRATORY PROTECTION FOR 1,1-DICHLOROETHANE

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
1000 ppm or less	Any chemical cartridge respirator with an organic vapor cartridge(s). Any supplied-air respirator. Any self-contained breathing apparatus.
4000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece. A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.
Greater than 4000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Option 1 - Full Display
RECORD# 1995 - 1,1-DICHLOROETHYLENE

0 ADMINISTRATIVE INFORMATION

HAZARDOUS SUBSTANCES DATABANK NUMBER - HSN	1995
LAST REVISION DATE - DATE	880513
RECORD LENGTH - RLEN	112204
LAST EDIT	06/08/88 by GCF
LAST RELEASE	03/12/87 by LS
DATE CREATED	ND
REVIEW DATE - RVDT	SRP review on 12/09/87
UPDATE HISTORY - UPDT(1)	Complete Update on 03/12/87

1 SUBSTANCE IDENTIFICATION

NAME OF SUBSTANCE - NAME	1,1-DICHLOROETHYLENE
CAS REGISTRY NUMBER - RN	75-35-4
RELATED HSDB RECORDS - RELT(1)	#6361, Trans-1,2-dichloroethylene ********** Comment - GCF (S-User) 06/08/88 THESE TWO RELTS ARE NOT IN THE RECORD CORRECTLY ... SEE MANUAL .... **********
RELATED HSDB RECORDS - RELT(2)	#5656, Cis-1,2-dichloroethylene
SYNONYMS - SY(1)	1,1-DCE ** UNREVIEWED **
SYNONYMS - SY(2)	1,1-DICHLOROETHENE ** UNREVIEWED **
SYNONYMS - SY(3)	ASYM-DICHLOROETHYLENE [MERCK INDEX. 10TH ED 1983 p 1430]

	** UNREVIEWED **
SYNONYMS - SY(4)	CHLORURE DE VINYLIDENE (FRENCH) ** UNREVIEWED **
SYNONYMS - SY(5)	ETHENE, 1,1-DICHLORO- ** PEER REVIEWED **
SYNONYMS - SY(6)	ETHYLENE, 1,1-DICHLORO- ** PEER REVIEWED **
SYNONYMS - SY(7)	NCI-C54262 ** UNREVIEWED **
SYNONYMS - SY(8)	VDC ** UNREVIEWED **

1 SUBSTANCE IDENTIFICATION (continued)

SYNONYMS - SY(9)	VINYLIDENE CHLORIDE ** PEER REVIEWED **
SYNONYMS - SY(10)	VINYLIDENE CHLORIDE (II) ** UNREVIEWED **
SYNONYMS - SY(11)	VINYLIDENE CHLORIDE (INHIBITED) ** UNREVIEWED **
SYNONYMS - SY(12)	VINYLIDENE DICHLORIDE ** UNREVIEWED **
SYNONYMS - SY(13)	VINYLIDINE CHLORIDE ** UNREVIEWED **
MOLECULAR FORMULA - MF	C2-H2-C12 ** PEER REVIEWED **
WISWESSER LINE NOTATION - WLN	ND
RTECS NUMBER - RTEC	NIOSH/KV9275000 ********** Comment - BO (ORNL) 08/25/87 There is an additional RTECS record for this CAS No. It is NIOSH/KV9275100. This is listed as the inhibited form and the DOT numbers are also for the inhibited form. **********
OHM-TADS NUMBER - OHMN	7216949
SHIPPING NAME/NUMBER - DOT/UN/NA/IMCO - SHPN(1)	UN 1303; Vinylidene chloride, inhibited
SHIPPING NAME/NUMBER - DOT/UN/NA/IMCO - SHPN(2)	IMCO 3.1; Vinylidene chloride
STCC NUMBER - STCC(1)	49 072 80; Vinylidene chloride, inhibited
EPA HAZARDOUS WASTE NUMBER - HAZN(1)	U078; 1,1-Dichloroethylene

2 MANUFACTURING/USE INFORMATION

METHODS OF MANUFACTURING - MMFG(1)

... FROM ETHYLENE CHLORIDE: REILLY, USA PATENT 2,140,548 (1938 TO DOW). BY DEHYDROCHLORINATION OF 1,1,2-TRICHLOROETHANE: CONRAD, GOULD, USA PATENT 2,989,570 (1961 TO ETHYL CORP). [MERCK INDEX. 10TH ED 1983 p 1430] ** UNREVIEWED **

2 MANUFACTURING/USE INFORMATION (continued)

METHODS OF MANUFACTURING - MMFG(2)

Vinylidene chloride has been prepared from vinyl chloride by successive chlorination and dehydrochlorination steps. [KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT 1:246 (78)] ** UNREVIEWED **

METHODS OF MANUFACTURING - MMFG(3)

CHLORINATION OF ETHYLENE DICHLORIDE TO 1,1,2-TRICHLOROETHANE FOLLOWED BY CAUSTIC DEHYDROCHLORINATION; THERMAL DEHYDROCHLORINATION OF 1,1,1-TRICHLOROETHANE (FORMER COMMERCIAL METHOD). [SRI] ** UNREVIEWED **

IMPURITIES - IMP(1)

Water content (75 ppm), acetylene (25 ppm), acidity as HCl (15 ppm), iron (0.5 ppm), MEHQ (180-220 ppm), trans-dichloroethylene (0.25%), 1,1-dichloroethane (0.25%), trichloroethylene (0.25%), ethylene dichloride (0.25%), peroxides (H2O2) (25 ppm). [CITATION Dow Chem Co; Vinylidene chloride Methyl Ether Hydroquinone (MEHQ) Inhibited. Quality Assurance Sales Specification Sheet (1970) as cited in USEPA; Phase I Document: Vinylidene Chloride p.5 (1981) EPA No. 68-01-6030] ** UNREVIEWED **

IMPURITIES - IMP(2)

A typical analysis of commercial-grade vinylidene chloride monomer (excluding inhibitors) is as follows: vinylidene chloride 99.8%; trans-1, 2-dichloroethylene 900 ppm; vinyl chloride 800 ppm; 1,1,1-trichloroethane 150 ppm; cis-1,2-dichloroethylene 10 ppm; and 1,1-dichloroethane, ethylene chloride, and trichloroethylene, each less than 10 ppm.

[CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-5 (1983) EPA-600/8-83-031A] ** UNREVIEWED **

FORMULATIONS/PREPARATIONS - FORM(1)

Inhibitors such as methyl ether hydroquinone (MEHQ) are generally added to Vinylidene chloride (VDC) monomer preparations ... to prevent polymerization and preserve the quality of the product during storage and shipment. Other compounds used as stabilizing agents include phenol, p-methoxyphenol, thymol, hydroquinone, alkylamines, and organic

2 MANUFACTURING/USE INFORMATION (continued)

FORMULATIONS/PREPARATIONS - FORM(1)-cont.

sulfur derivatives.
[KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT 5:178 (79)] ** UNREVIEWED **

FORMULATIONS/PREPARATIONS - FORM(2)

Liquid grade
[CITATION CHEMCYCLOPEDIA 1986 p.120]
** UNREVIEWED **

MANUFACTURERS - MFS(1)

Dow Chemical Co, Hq, 2020 Dow Center, Midland, MI 48640 (517) 636-1000
[McCURDY. CHEM WEEK BUY GUIDE 1987. p 559]
** UNREVIEWED **

MANUFACTURERS - MFS(2)

PPG Indust, Inc, Chem Div, Indust Chem Div, Hq, One PPG Place, Pittsburg, PA 15272 (412) 434-3131
[McCURDY. CHEM WEEK BUY GUIDE 1987. p 559]
** UNREVIEWED **

MANUFACTURERS - MFS(3)

VULCAN MATERIALS CO, CHEMICALS DIVISION, WICHITA, KANSAS 67201 (INHIBITED)
[CHRIS. HAZARD CHEM DATA MANUAL. 2 1978]
** PEER REVIEWED **
****
Comment - KFG (ORNL) 08/26/87
This info not found in source update 224.
****

OTHER MANUFACTURING INFORMATION - OMIN(1)

Other /manufacturing/ methods are based on bromochloroethane, trichloroethyl acetate, tetrachloroethane, and catalytic cracking of trichloroethane.
[KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT V23 764] ** UNREVIEWED **

OTHER MANUFACTURING INFORMATION - OMIN(2)

Vinylidene chloride is purified by washing with water, drying, and fractillation. It forms an azeotrope with 6 wt% methanol.

Purification can be by distillation of the azeotrope followed by extraction of methanol with water
[KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT 23:764 (83)] ** UNREVIEWED **

OTHER MANUFACTURING INFORMATION - OMIN(3)

Most common test methods indicate that vinylidene chloride polymers have a low degree of flammability. Their limiting oxygen index is 60. ... Their resistance to combustion is not only a function of their high chlorine content, but is also related to their tendency to

2 MANUFACTURING/USE INFORMATION (continued)

OTHER MANUFACTURING INFORMATION - OMIN(3)-cont.

dehydrochlorinate into a carbonaceous char highly resistant to combustion.
[LANDROCK. HDBK PLASTICS FLAM & COMB TOX 1983 p 49] ** UNREVIEWED **

MAJOR USES - USE(1)

IN ADHESIVES
[HAWLEY. CONDENSED CHEM DICTNRY 10TH ED 1981 p 1086] ** UNREVIEWED **

MAJOR USES - USE(2)

Used as an intermediate in vinylidene fluoride synthesis.
[KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT 11:65 (80)] ** UNREVIEWED **

MAJOR USES - USE(3)

Vinylidene chloride is used as a monomeric intermediate in the production of plastics, particularly the saran types.
[CITATION De Serres FJ, Hollaender A; Chemical Mutagens Vol 4 p.261 (1976)] ** UNREVIEWED **

MAJOR USES - USE(4)

COMONOMER, ESP FOR FOOD PACKAGING & COATING RESINS
[SRI] ** PEER REVIEWED **

MAJOR USES - USE(5)

COMONOMER FOR MODACRYLIC FIBERS
[SRI] ** PEER REVIEWED **

MAJOR USES - USE(6)

MONOMER FOR SARAN FIBERS
[SRI] ** PEER REVIEWED **

MAJOR USES - USE(7)

UNISOLATED CHEMICAL INTERMEDIATE FOR 1,1,1-TRICHLORDETHANE
[SRI] ** UNREVIEWED **

MAJOR USES - USE(8)

Chemical intermediate in production of chloracetyl chloride.
[CITATION USEPA; Health Assessment

	Document: Vinylidene Chloride p.5-15 (1983) EPA-600/8-83-031A] ** UNREVIEWED **
CONSUMPTION PATTERNS - CPAT(1)	Virtually all of the vinylidene chloride produced is used in the production of copolymers with vinyl chloride or acrylonitrile. A small percentage (4%) of vinylidene chloride is used as chemical intermediates (1985) [CITATION USEPA; Health Assessment Document for Vinylidene Chloride p.1-1 (1985) EPA/600/8-83/031A] ** UNREVIEWED **

2 MANUFACTURING/USE INFORMATION (continued)

U.S. PRODUCTION - PROD(1)	(1977) 9.1X10+10 G MIN-MAY INCL CAPTIVE PRODN [SRI] ** PEER REVIEWED **
U.S. PRODUCTION - PROD(2)	(1980) 7.8X10+10 G (EST, EXCL CAPTIVE PRODN) [SRI] ** PEER REVIEWED **
U.S. PRODUCTION - PROD(3)	(1985) 8.08X10+10 g (capacity) [CITATION USEPA; Health Assessment Document for Vinylidene Chloride p.1-1 (1985) EPA/600/8-83/031F] ** UNREVIEWED **
U.S. IMPORTS - IMPT(1)	(1977) 1.63X10+7 G [SRI] ** PEER REVIEWED **
U.S. IMPORTS - IMPT(2)	(1982) 4.60X10+5 G [SRI] ** PEER REVIEWED **
U.S. IMPORTS - IMPT(3)	(1984) 1.81X10+7 g [CITATION BUREAU OF THE CENSUS. U.S. IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1984 p.1-363] ** UNREVIEWED **
U.S. EXPORTS - EXPT(1)	(1977) ND [SRI] ** PEER REVIEWED **
U.S. EXPORTS - EXPT(2)	(1982) ND [SRI] ** PEER REVIEWED **
U.S. EXPORTS - EXPT(3)	(1986) ND [CITATION] ** UNREVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES

COLOR/FORM - COFO(1)	Colorless liquid [VERSCHUEREN. HDBK ENVIRON DATA ORG CHEM 1983 p 487] ** UNREVIEWED **
ODOR - ODOR(1)	MILD, SWEET ODOR RESEMBLING THAT OF CHLOROFORM [MERCK INDEX. 10TH ED 1983 p 1430] ** UNREVIEWED **
TASTE - TAST(1)	ND
BOILING POINT - BP	31.7 DEG C @ 760 MM HG [MERCK INDEX. 10TH ED 1983 p 1430] ** UNREVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

MELTING POINT - MP(1)	-122.5 DEG C [MERCK INDEX. 10TH ED 1983 p 1430] ** UNREVIEWED **
MOLECULAR WEIGHT - MW	ND
CORROSIVITY - CORR(1)	Vinylidene chloride may be corrosive or unstable in the presence of steel. [CITATION USEPA; Air Pollution Assessment of Vinylidene Chloride p.1-74 (1978) EPA 68-02-1495] ** UNREVIEWED **
CRITICAL TEMPERATURE & PRESSURE - CTP(1)	ND
DENSITY/SPECIFIC GRAVITY - DEN	1.2129 @ 20 DEG C/4 DEG C [MERCK INDEX. 10TH ED 1983 p 1430] ** UNREVIEWED **
DISSOCIATION CONSTANTS - DSC(1)	ND
HEAT OF COMBUSTION - HTC	-2700 CAL/G (INHIBITED) [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **
HEAT OF VAPORIZATION - HTV	72 CAL/G (INHIBITED) [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **
OCTANOL/WATER PARTITION COEFFICIENT - OWPC	log Kow= 1.32 (est) [CITATION Leo A et al; Chem Rev 71 (6): 552-8 (1971) as cited in USEPA; Phase I Document: Vinylidene Chloride p.22 (1981) EPA No. 68-01-6030] ** UNREVIEWED **
PH - PH	ND

SOLUBILITIES - SOL(1)

0.04% WT/VOL IN WATER @ 20 DEG C
[IARC MONOGRAPHS. 1972-PRESENT
V19 440 (1979)] ** UNREVIEWED **

SOLUBILITIES - SOL(2)

SOL IN ALC, ACETONE, BENZENE; VERY SOL IN ETHER & CHLOROFORM
[WEAST. HDBK CHEM & PHYS 66TH ED 1985-86 C-272] ** UNREVIEWED **

SOLUBILITIES - SOL(3)

0.63 g/100 g water at 50 deg C (solubility at saturation vapor pressure).
[KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT 14:83 (81)] ** UNREVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

SOLUBILITIES - SOL(4)

In water: 3.5 g/l at 4 deg C; 3.0 g/l at 16 deg C; 2.5 g/l at 25 deg C.
[CITATION Dow Chem Co; Vinylidene Chloride Monomer: Safe Handling Guide (1980)]
** UNREVIEWED **

SOLUBILITIES - SOL(5)

Water solubility: 2250 mg/l at 25 deg C
[CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.1-1 (1983) EPA-600/8-83-031A] ** UNREVIEWED **

SOLUBILITIES - SOL(6)

MISCIBLE WITH MOST ORG SOLVENTS
[IARC MONOGRAPHS. 1972-PRESENT
V19 440 (1979)] ** UNREVIEWED **

SPECTRAL PROPERTIES - SPEC(1)

MAX ABSORPTION (VAPOR): LESS THAN 200 NM
[WEAST. HDBK CHEM & PHYS 60TH ED 1979 C-298]
** PEER REVIEWED **
****
Comment - KFG (ORNL) 08/31/87
This info not found in source update 222.
****

SPECTRAL PROPERTIES - SPEC(2)

INDEX OF REFRACTION: 1.4249 @ 20 DEG C/D
[MERCK INDEX. 10TH ED 1983 p 1430]
** UNREVIEWED **

SURFACE TENSION - SURF

24 DYNES/CM @ 15 DEG C (INHIBITED)
[CHRIS. HAZARD CHEM DATA VOL. II 1984-5]
** UNREVIEWED **

VAPOR DENSITY - VAPD

3.4 /Air=1/
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-38] ** UNREVIEWED **

VAPOR PRESSURE - VAP

591 MM HG @ 25 DEG C
[PATTY. INDUS HYG & Y 3RD ED VOL2A,2B,2C

TO.
1981-82 p 3545] ** UNREVIEWED **

ORIGINAL (Red)

RELATIVE EVAPORATION RATE - EVAP(1)

... The evaporation half-life of a dilute aq soln of vinylidene chloride (1 ppm w/w) in an open container stirred at 200 rpm at 25 deg C /was/ 22 min, 90% of the cmpd was lost in 89 min.
[CITATION Dilling WL et al; Envir Sci Technol 9 (9): 833-838 (1975) as cited in USEPA; Phase I Document: Vinylidene Chloride p.29 (1981) EPA No. 68-01-6030]
** UNREVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

VISCOSITY - VISC

0.3302 cp at 20 deg C
[CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-3 (1983) EPA-600/8-83-031A] ** UNREVIEWED **

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(1)

HEAT OF POLYMERIZATION: -185 CAL/G (INHIBITED); VAPOR (GAS) SPECIFIC GRAVITY: 3.3 (INHIBITED)
[CHRIS. HAZARD CHEM DATA VOL. II 1984-5]
** UNREVIEWED **

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(2)

The water/air partition coefficient at 20 deg C is 0.16.
[CITATION Pearson CR, McConnell G; Proc R Soc London Ser B 189: 305-32 (1975)]
** UNREVIEWED **

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(3)

Heat of combustion: -4860 Btu/lb= -2700 cal/g
[CHRIS. HAZARD CHEM DATA VOL. II 1984-5]
** UNREVIEWED **

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(4)

Liquid density at 0 deg C: 1.2517 g/cu m
[CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-2 (1983) EPA-600/8-83-031A] ** UNREVIEWED **

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(5)

Latent heat of vaporization at 25 deg C: 6328 cal/mol
[CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-3 (1983) EPA-600/8-83-031A] ** UNREVIEWED **

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(6)

Latent heat of vaporization at boiling point: 6257 cal/mol.
[CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-3 (1983)

EPA-600/8-83-031A] ** UNREVIEWED **

ORIGINAL (Red)

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(7)	Latent heat of fusion: 1557 cal/mol. [CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-3 (1983) EPA-600/8-83-031A] ** UNREVIEWED **
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(8)	Specific heat: 0.275 ca/9 [CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-3 (1983) EPA-600/8-83-031A] ** UNREVIEWED **
OTHER CHEMICAL/PHYSICAL	Dielectric constant 4.67 at 16 deg C.

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(9)-cont.	[CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-3 (1983) EPA-600/8-83-031A] ** UNREVIEWED **
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(10)	Heat of polymerization: -18.0 Kcal/mol. [CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-3 (1983) EPA-600/8-83-031A] ** UNREVIEWED **
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(11)	Heat of formation (liquid monomer): -6 Kcal/mol; Heat of formation (gaseous monomer): 0.3 Kcal/mol [CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-3 (1983) EPA-600/8-83-031A] ** UNREVIEWED **
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(12)	Heat capacity at 25.15 deg C (liquid monomer): 26.745 cal/mol/deg. [CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-3 (1983) EPA-600/8-83-031A] ** UNREVIEWED **
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(13)	Octanol/water partition coefficient (log Kow= 1.48(1)). [CITATION (1) Tute MS; Adv Drug Res 6: 1-77 (1971)] ** UNREVIEWED **
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(14)	Evaporation from water at 25 deg C of 1 ppm solution: 50% after 22 min; 90% after 89 min. [VERSCHUEREN.HDBK ENVIRON DATA ORG CHEM 1983 p 488] ** UNREVIEWED **

4 SAFETY AND HANDLING

HAZARDS SUMMARY - HAZS(1)	ND

DOT EMERGENCY GUIDELINES - DOT(1)

Fire or Explosion: Flammable/combustible material; may be ignited by heat, sparks or flames. Vapors may travel to a source of ignition and flash back. Container may explode in heat of fire. Vapor explosion hazard indoors, outdoors, or in sewers. Runoff to sewer may create fire, or explosion hazard.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1984 G-26] ** UNREVIEWED **

DOT EMERGENCY GUIDELINES -

Health Hazard: May be poisonous if inhaled

4 SAFETY AND HANDLING (continued)

DOT EMERGENCY GUIDELINES - DOT(2)-cont.

or absorbed through skin. Vapors may cause dizziness or suffocation. Contact may irritate or burn skin and eyes. Fire may produce irritating or poisonous gases. Runoff from fire control, or dilution water may cause pollution.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1984 G-26] ** UNREVIEWED **

DOT EMERGENCY GUIDELINES - DOT(3)

Emergency Action: Keep unnecessary people away; isolate hazard area and deny entry. Stay upwind; keep out of low areas. Wear self-contained (positive pressure if available) breathing apparatus and full protective clothing. Isolate for 1/2 mile in all directions if tank car or truck is involved in fire. If water pollution occurs, notify appropriate authorities.
FOR EMERGENCY ASSISTANCE CALL CHEMTREC (800) 424-9300
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1984 G-26] ** UNREVIEWED **

DOT EMERGENCY GUIDELINES - DOT(4)

Fire: Small Fires: Dry chemical, CO2, water spray, or alcohol foam. Large Fires: Water spray, fog, or alcohol foam. Move container from fire area if you can do it without risk. Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1984 G-26] ** UNREVIEWED **

DOT EMERGENCY GUIDELINES - DOT(5)

Spill or Leak: Shut off ignition sources; no flares, smoking, or flames in hazard area. Stop leak if you can do it without risk. Use water spray to reduce vapors. Small Spills: Take up with sand, or other non-combustible absorbent material and place into containers for later disposal. Large Spills: Dike far ahead of spill for later disposal.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1984 G-26] ** UNREVIEWED **

4 SAFETY AND HANDLING (continued)

DOT EMERGENCY GUIDELINES - DOT(6)

First Aid: Move victim to fresh air; call emergency medical care. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact with material, immediately flush eyes with running water for at least 15 min. Wash skin with soap and water. Remove and isolate contaminated clothing and shoes at the site.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1984 G-26] ** UNREVIEWED **

FIRE POTENTIAL - FPOT(1)

Burning rate: 2.7 mm/min [49 CFR 172.101 (10/01/81)] Flammable liquid
[CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **

FIRE POTENTIAL - FPOT(2)

Flammable liquid
[CITATION 49 CFR 172.101 (10/01/86)] ** UNREVIEWED **

NFPA HAZARD CLASSIFICATION - NFPA(1)

Health: 2. 2= Materials hazardous to health, but areas may be entered freely with self-contained breathing apparatus.
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-38] ** UNREVIEWED **

NFPA HAZARD CLASSIFICATION - NFPA(2)

Flammability: 4. 4= Very flammable gases, very volatile flammable liquids, and materials that in the form of dusts or mists readily form explosive mixtures when dispersed in air. Shut off flow of gas or liquid and keep cooling water streams on exposed tanks or containers. Use water spray carefully in the vicinity of dusts so as not to create dust clouds.
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH

ED 1986 49-38] ** UNREVIEWED **

NFPA HAZARD CLASSIFICATION - NFPA(3)

Reactivity: 2. 2= Materials which in themselves are normally unstable & readily undergo violent chemical change but do not detonate. ... Also ... materials which may react violently with water or ... may form potentially explosive mixtures with water. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-38] ** UNREVIEWED **

FLAMMABLE LIMITS - FLMT(1)

LOWER 7.3%; UPPER 16%.
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-38] ** UNREVIEWED **

4 SAFETY AND HANDLING (continued)

FLASH POINT - FLPT(1)

3 deg F (open cup); -2 deg F (closed cup). [CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-3 (1983) EPA-600/8-83-031A] ** UNREVIEWED **

AUTOIGNITION TEMPERATURE - AUTO

IGNITION TEMP, 1058 DEG F.
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-38] ** UNREVIEWED **

FIRE FIGHTING PROCEDURES - FIRP(1)

In advanced or massive fires, fire fighting should be done from a safe distance or from a protected location. Use dry chemical, foam, or carbon dioxide. Water may be ineffective, but water should be used to keep fire-exposed containers cool. If a leak or spill has not ignited, use water spray to disperse the vapors. If it is necessary to stop a leak, use water spray to protect men attempting to do so. Water spray may be used to flush spills away from exposures. ... Vapors are uninhibited and may form polymers in vents and flame arresters, resulting in stoppage of vents.
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-38] ** UNREVIEWED **

FIRE FIGHTING PROCEDURES - FIRP(2)

If material on fire or involved in fire: Do not extinguish fire unless flow can be stopped. Use water in flooding quantities as fog. Solid streams of water spread fire. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Use foam, dry chemical, or carbon dioxide.
[AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 244] ** UNREVIEWED **

INTENSITY OF HEAT - INTH(1)	ND
TOXIC COMBUSTION PRODUCTS - TOXC(1)	IF ... IGNITED, HIGHLY TOXIC HYDROGEN CHLORIDE IS LIKELY TO BE EVOLVED. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-38] ** UNREVIEWED **
OTHER FIRE FIGHTING HAZARDS - OFHZ(1)	... VAPOR IS HEAVIER THAN AIR ... AND MAY TRAVEL CONSIDERABLE DISTANCE TO SOURCE OF IGNITION & FLASH BACK. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-38] ** UNREVIEWED **

4 SAFETY AND HANDLING (continued)

EXPLOSIVE LIMITS AND POTENTIAL - EXPL(1)	VAPOR FORMS EXPLOSIVE MIXT WITH AIR. ... @ ELEVATED TEMP ... POLYMERIZATION MAY TAKE PLACE. /IF SO/, THERE IS POSSIBILITY OF VIOLENT RUPTURE OF CONTAINER. ... ON LONG STANDING WHITE DEPOSIT MAY FORM, WHICH IS READILY EXPLODABLE PEROXIDE. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-38] ** UNREVIEWED **
EXPLOSIVE LIMITS AND POTENTIAL - EXPL(2)	VINYLIDENE CHLORIDE IN THE PRESENCE OF AIR OR OXYGEN, WITH THE INHIBITOR REMOVED, FORMS A COMPLEX PEROXIDE CMPD AT TEMP AS LOW AS -40 DEG C. THE PEROXIDE IS VIOLENTLY EXPLOSIVE. REACTION PRODUCTS FORMED WITH OZONE ARE PARTICULARLY DANGEROUS. [PATTY. INDUS HYG & TOX 3RD ED VOL2A,2B,2C 1981-82 p 3546] ** UNREVIEWED **
EXPLOSIVE LIMITS AND POTENTIAL - EXPL(3)	Lower 5.6%; upper 11.4% [ITI. TOX & HAZARD INDUS CHEM SAFETY MANUAL 1982 p 555] ** UNREVIEWED **
EXPLOSIVE LIMITS AND POTENTIAL - EXPL(4)	On long standing a white deposit may form, which is a readily explodable peroxide. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-38] ** UNREVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(1)	At ambient temp, perchloryl fluoride is unreactive with 1,1-dichloroethylene, but reaction is explosive at 100-300 deg C, or if the mixture is ignited. [BRETHERICK. HDBK REACTIVE CHEM HAZARDS 1985 p 232] ** UNREVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(2)	Condensation of trichlorotrifluoroethylene and 1,1-dichloroethylene at 180 deg C

under pressure to give 1,1,2-trichloro-2,3,3-trifluorocyclobutane was effected smoothly several times in a 1 liter autoclave. Scaling up to a 3 liter autoclave led to uncontrolled polymerization which distorted the autoclave.
[BRETHERICK. HDBK REACTIVE CHEM HAZARDS 1985 p 232] ** UNREVIEWED **

DECOMPOSITION - DCMP(1) — WHEN NOT STABILIZED, DECOMP IN AIR INTO CHLORINE, HYDROGEN CHLORIDE, PHOSGENE, & FORMALDEHYDE & WHITE POLYMERIC POWDER

4 SAFETY AND HANDLING (continued)

DECOMPOSITION - DCMP(1)-cont. — [LEFAUX. PRAC TOX OF PLASTICS 1968 p 84] ** PEER REVIEWED **

POLYMERIZATION - POLY(1) — POLYMERIZATION CAN OCCUR IF EXPOSED TO SUNLIGHT, AIR, COPPER, ALUMINUM, OR HEAT.
[CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **

POLYMERIZATION - POLY(2) — Under controlled polymerization, forms an explosive reaction product with oxygen, or ozone.
[ITI. TOX & HAZARD INDUS CHEM SAFETY MANUAL 1982 p 555] ** UNREVIEWED **

POLYMERIZATION - POLY(3) — When stored between -40 and +25 deg C in the absence of inhibitor and presence of air, vinylidene chloride rapidly absorbs oxygen with formation of a violently explosive peroxide. The latter initiates polymerization, producing an insoluble polymer which adsorbs the peroxide. Separation of this polymer in a dry state must be avoided, since if more than 15% of peroxide is present, the polymer may be detonable by slight shock or heat. Hindered phenols are suitable inhibitors to prevent peroxidation.
[BRETHERICK. HDBK REACTIVE CHEM HAZARDS 1985 p 231] ** UNREVIEWED **

POLYMERIZATION - POLY(4) — In the presence of polymerization initiators, vinylidene chloride undergoes self-polymerizaton to form homopolymers, or polymerizes with other compounds, /such as/ vinyl chloride, alkylacrylates, and acrylonitrile to form copolymers.
[CITATION USEPA; Health Assessment Document: Vinylidene Chloride p.3-5 (1983)

EPA-600/8-83-031A] ** UNREVIEWED **

OTHER HAZARDOUS REACTIONS - OHAZ(1): ND

ODOR THRESHOLD - ODRT(1): MOST PERSONS CAN DETECT MILD BUT DEFINITE ODOR @ 1000 PPM IN AIR. SOME ... CAN DETECT IT @ 500 PPM. VAPORS CONTAINING DECOMP PRODUCTS HAVE DISAGREEABLE ODOR AND CAN BE DETECTED @ CONCN CONSIDERABLY LESS THAN 500 PPM. NEITHER ODOR NOR IRRITATING PROPERTIES OF VINYLIDENE CHLORIDE IS ADEQUATE TO WARN OF EXCESSIVE EXPOSURE.

4 SAFETY AND HANDLING (continued)

ODOR THRESHOLD - ODRT(1)-cont.: [PATTY. INDUS HYG & TOX 3RD ED VOL2A,2B,2C 1981-82 p 3550] ** UNREVIEWED **

SKIN, EYE AND RESPIRATORY IRRITATIONS - SERI(1): Vapor is irritating to eyes, nose and throat. ... Liquid ... causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure.
[CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **

PROTECTIVE EQUIPMENT & CLOTHING - EQUP(1): APPROVED CANISTER OR AIR-SUPPLIED MASK; GOGGLES OR FACE SHIELD; RUBBER GLOVES AND BOOTS (INHIBITED).
[CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **

OTHER PREVENTIVE MEASURES - OPRM(1): The primary requirement for reduction of exposure to vinylidene chloride would be to limit emissions through improved housekeeping procedures in the industry.
[SITTIG. HANDBOOK TOXIC HAZARD CHEM & CARCINOG 2 ED 85 p 925] ** UNREVIEWED **

OTHER PREVENTIVE MEASURES - OPRM(2): If material not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak if without undue personal hazard. Use water spray to knock down vapors.
[AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 244] ** UNREVIEWED **

OTHER PREVENTIVE MEASURES - OPRM(3): Personnel protection: Avoid breathing vapors. Keep upwind. Wear positive pressure self-contained breathing

apparatus when fighting fires involving this material.
[AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 244] ** UNREVIEWED **

OTHER PREVENTIVE MEASURES - OPRM(4)

Evacuation: If fire becomes uncontrollable, or container is exposed to direct flame, evacuate for a radius of 2500 ft. If material is leaking and not on fire, downwind evacuation must be considered.
[CITATION Bureau of Explosives; Emergency Handling of Haz Matl in Surface Trans p.527 (1981)] ** UNREVIEWED **

4 SAFETY AND HANDLING (continued)

****
Comment - DES (Dynamac) 04/13/88
This occurrence is not in source update.
****

STABILITY/SHELF LIFE - SSL(1)

ND

SHIPMENT METHODS AND REGULATIONS - SHIP(1)

Whenever hazardous materials are to be transported, Title 49 CFR, Transportation, Parts 100-180, published by the US Dept of Transportation, contain the regulatory requirements and must be consulted.
[CITATION 52 FR 16482 (5/5/87)]
** UNREVIEWED **

SHIPMENT METHODS AND REGULATIONS - SHIP(2)

Shipping description: Vinylidene chloride, inhibited, 3, UN1303. Label(s) required: Flammable liquid. Acceptable Modes of transportation: Air, rail, road, and water.
[CITATION 52 FR 16666 (5/5/87)]
** UNREVIEWED **

SHIPMENT METHODS AND REGULATIONS - SHIP(3)

Int'l Air Shipments: Shipping description: Vinylidene chloride, inhibited, 3, UN1303. Label(s) required: Flammable liquid. Packaging Instructions: 5.3.303 (passenger); 5.3.302 (cargo).
[IATA. DANGEROUS GOODS REGS (AIR TRANS) 28TH ED 1987 p 221] ** UNREVIEWED **

SHIPMENT METHODS AND REGULATIONS - SHIP(4)

Int'l Air Shipments: Shipping description: Vinylidene chloride, uninhibited, 3, UN1303. Prohibited for transport on cargo or passenger aircraft.
[IATA. DANGEROUS GOODS REGS (AIR TRANS) 28TH ED 1987 p 221] ** UNREVIEWED **

SHIPMENT METHODS AND

Water shipments: Shipping description:

REGULATIONS - SHIP(5)

Vinylidene chloride, inhibited, 3, UN1303. Label(s) required: Flammable liquid. [CITATION IMDG; International Maritime Dangerous Goods Code; International Maritime Organization (1986)] ** UNREVIEWED **

STORAGE CONDITIONS - STRG(1)

PROTECT AGAINST PHYSICAL DAMAGE. OUTSIDE OR DETACHED STORAGE IS PREFERABLE. INSIDE STORAGE SHOULD BE IN STD FLAMMABLE LIQUIDS STORAGE ROOM OR CABINET. SEPARATE FROM OXIDIZING MATERIALS.
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-39] ** UNREVIEWED **

4 SAFETY AND HANDLING (continued)

STORAGE CONDITIONS - STRG(2)

Vinylidene chloride must be stored in tanks that have nickel, baked phenolic, or glass linings.
[CITATION USEPA; Air Pollution Assessment of Vinylidene Chloride p.1-74 (1978) EPA 68-02-1495] ** UNREVIEWED **

STORAGE CONDITIONS - STRG(3)

Vinylidene chloride is generally stored at -10 deg C, in the absence of light, air, water, and other polymerization initiators under a nitrogen blanket at 10 psi pressure; the oxygen content of the nitrogen should remain at less than 100 ppm.
[CITATION Dow Chem Co; Vinylidene Chloride Monomer: Safe Handling Guide (1980) as cited in USEPA; Phase I Document: Vinylidene Chloride p.20 (1981) EPA No. 68-01-6030] ** UNREVIEWED **

CLEANUP METHODS - CLUP(1)

/SRP: For lab spills/ Absorb the spills with paper towels, or like materials. Place in a hood to evaporate.
[ITI. TOX & HAZARD INDUS CHEM SAFETY MANUAL 1982 p 555] ** UNREVIEWED **

CLEANUP METHODS - CLUP(2)

Environmental considerations: Land spill: Dig a pit, pond, lagoon, or holding area to contain liquid or solid material. Dike surface flow using soil, sand bags, foamed polyurethane, or foamed concrete. Absorb bulk liquid with fly ash, cement powder, sawdust, or commercial sorbents. Apply fluorocarbon-water foam to diminish vapor and fire hazard. /SRP: If time permits, pits, ponds, lagoons, soak holes, or holding areas should be sealed with an

impermeable flexible membrane liner./
[CITATION Bureau of Explosives; Emergency Handling of Haz Matl in Surface Trans p.527 (1981)] ** UNREVIEWED **
****
Comment - DES (Dynamac) 04/13/88
This occurrence not in source update.
****

CLEANUP METHODS - CLUP(3)

Environmental considerations: Water spill: Use natural deep water pockets, excavated lagoons, or sand bag barriers to trap material at bottom. /SRP: If time permits,

4 SAFETY AND HANDLING (continued)

CLEANUP METHODS - CLUP(3)-cont.

pits, ponds, lagoons, soak holes, or holding areas should be sealed with an impermeable flexible membrane liner./ Remove trapped material with suction hoses. Use mechanical dredges or lifts to remove immobilized masses of pollutants and precipitates. Inject "universal" gelling agent to solidify encircled spill and increase effectiveness of booms.
[CITATION Bureau of Explosives; Emergency Handling of Haz Matl in Surface Trans p.527 (1981)] ** UNREVIEWED **
****
Comment - DES (Dynamac) 04/18/88
This occurrence not in source update
****

CLEANUP METHODS - CLUP(4)

Environmental considerations: Air spill: Apply water spray or mist to knock down vapors. Combustion products include corrosive or toxic vapors.
[CITATION Bureau of Explosives; Emergency Handling of Haz Matl in Surface Trans p.527 (1981)] ** UNREVIEWED **
****
Comment - DES (Dynamac) 04/18/88
This occurrence not in source update
****

DISPOSAL METHODS - DISP(1)

At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
[CITATION SRP] ** UNREVIEWED **

DISPOSAL METHODS - DISP(2)

Incineration, preferably after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced.
[SITTIG. HANDBOOK TOXIC HAZARD CHEM & CARCINOG 2 ED 85 p 925] ** UNREVIEWED **

DISPOSAL METHODS - DISP(3)

A potential candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of

4 SAFETY AND HANDLING (continued)

DISPOSAL METHODS - DISP(3) -cont.

seconds for liquids and gases, and longer for solids. Also a potential candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. Also a potential candidate for liquid injection incineration at a temperature range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds.
[CITATION USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-12 (1981) EPA 68-03-3025] ** UNREVIEWED **

DISPOSAL METHODS - DISP(4)

This compound should be susceptible to removal from waste water by air stripping.
[CITATION USEPA/ORD; Innovative and Alternative Technology Assessment Manual pp.3-5, 3-11,12 (1980) EPA 430/9-78-009] ** UNREVIEWED **

DISPOSAL METHODS - DISP(5)

Chemical Treatability of 1,1-Dichloroethylene; Concentration Process: Stripping; Chemical Classification: Halocarbons; Scale of Study: Literature Review; Type of Wastewater Used: Unknown; Results of Study: Air and steam strippable.
[CITATION Dryden FE et al; EPA Contract No. 68-03-2579 (1978) as cited in USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-100 (1982)] ** UNREVIEWED **

DISPOSAL METHODS - DISP(6)

Chemical Treatability of 1,1-Dichloroethylene; Concentration Process: Stripping; Chemical Classification: Halocarbons; Scale of Study: Pilot Scale/Continuous Flow; Type of Wastewater

Used: Industrial; Influent Concentration: 61.5 ppm at 250 ml/ min feed rate; Results of Study: Overhead flow (% of feed), Overhead Concn (ppm), Bottom Concn (ppm); 2.3, 3,511.8, 114.1, respectively; 2.8, 3,277.0, 89.5; 5.1, 2,736.5, 175.6; 2.5 with 1.4:1 reflux to overhead ratio, 5159, 131.7; (Water quality: TOC 9022, COD 15,100 ppm, pH 0.1, acidity 102,312 ppm, Cl 116,127 ppm, numerous other halogens present).
[CITATION Coco JH et al; EPA-600/2-77-186a (1977) as cited in USEPA; Management of

ORIGINAL (Red)

4 SAFETY AND HANDLING (continued)

DISPOSAL METHODS - DISP(6) -cont.	Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-100 (1982)] ** UNREVIEWED ** ********** Comment - GCF (S-User) 06/08/88 DISP6-7 COCO AND DYDEN PAPER WHAT IS THE TITLE? **********
DISPOSAL METHODS - DISP(7)	Chemical Treatability of 1,1-Dichloroethylene; Concentration Process: Solvent Extraction; Chemical Classification: Halocarbons; Scale of Study: Literature Review; Type of Wastewater Used: Unknown; Results of Study: Extractable with alcohols, aromatics, and ethers. [CITATION Dryden FE et al; EPA Contract No. 68-03-2579 (1978) as cited in USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-115 (1982)] ** UNREVIEWED **
RADIATION LIMITS AND POTENTIAL - RADL(1)	ND

5 TOXICITY/BIOMEDICAL EFFECTS

TOXICITY SUMMARY - TOXS(1)	ND
TOXIC HAZARD RATING - TXHR(1)	Classification of carcinogenicity: 1) evidence in humans: inadequate; 2) evidence in animals: limited; 3) evidence for activity in short-term tests: sufficient. Summary evaluation of carcinogenic risk to humans 3: The chemicals, group of chemicals, industrial

	processes or occupational exposure cannot be classified as to its carcinogenicity to humans. /From table/ [IARC MONOGRAPHS. 1972-PRESENT S4 22 (1982)] ** UNREVIEWED **
POISONING POTENTIAL - PPOT(1)	ND
ANTIDOTE AND EMERGENCY TREATMENT - ANTR(1)	ND
MEDICAL SURVEILLANCE - MEDS(1)	Physical examination of exposed personnel, including studies of liver and kidney

5 TOXICITY/BIOMEDICAL EFFECTS (continued)

MEDICAL SURVEILLANCE - MEDS(1) -cont.	functions. [ITI. TOX & HAZARD INDUS CHEM SAFETY MANUAL 1982 p 555] ** PEER REVIEWED **
HUMAN TOXICITY EXCERPTS - HTOX(1)	ACUTE EXPOSURE TO HIGH CONCN OF VINYLIDENE CHLORIDE IN AIR RESULTS IN CNS DEPRESSION ... REPEATED EXPOSURES TO LOW CONCN ARE ASSOC WITH LIVER & RENAL DYSFUNCTION. SKIN CONTACT WITH VINYLIDENE CHLORIDE CAUSES IRRITATION, WHICH MAY PARTLY BE DUE TO HYDROQUINONE MONOMETHYL ETHER INHIBITOR. [IARC MONOGRAPHS. 1972-PRESENT V19 447 (1979)] ** UNREVIEWED **
HUMAN TOXICITY EXCERPTS - HTOX(2)	Dow Chemical Co reported that acute exposure to VDC vapor at approximately 4,000 ppm (1.58 g/cu m) causes symptoms of drunkenness that may progress to unconsciousness if exposure is continued for longer than a few minutes and that complete recovery occurs when exposure is of short duration. [CITATION Dow Chemical Co; Vinylidene Chloride Monomer: Safe Handling Guide (1980) as cited in USEPA; Phase I Document: Vinylidene Chloride p.76 (1981) EPA No. 68-01-6030] ** UNREVIEWED **A
HUMAN TOXICITY EXCERPTS - HTOX(3)	CONTACT WITH EYE CAUSES CONJUNCTIVITIS & TRANSIENT CORNEAL INJURY. ... [IARC MONOGRAPHS. 1972-PRESENT V19 447 (1979)] ** UNREVIEWED **A
NON-HUMAN TOXICITY EXCERPTS - NTOX(1)	... GROUPS OF 50 MALE & 50 FEMALE SPRAGUE-DAWLEY RATS ... ADMIN 5, 10 OR 20 MG/KG BODY WT VINYLIDENE CHLORIDE IN OLIVE OIL BY STOMACH TUBE ONCE DAILY ON 4-5 DAYS/WK FOR 52 WK; 1 CARCINOMA OF ZYMBAL GLAND ...

OBSERVD IN RAT TREATED WITH 10 MG/KG BODY WT AT TIME OF REPORTING, RATS HAD BEEN OBSERVED FOR 93 WK OF TREATMENT (MALTONI ET AL, 1977).
[IARC MONOGRAPHS. 1972-PRESENT V19 443 (1979)] ** UNREVIEWED **A

ORIGINAL (13-3d)

NON-HUMAN TOXICITY EXCERPTS - NTOX(2)

GROUP OF 36 MALE & 36 FEMALE CD-1 MICE, 2 MO OF AGE WERE EXPOSED TO ... (55 PPM) VINYLIDENE CHLORIDE IN AIR FOR 6 HR/DAY ON 5 DAYS A WK FOR 12 MO ... BRONCHIOLO-ALVEOLAR ADENOMAS ... IN 6 MICE & ANGIOSARCOMAS OF LIVER ... IN 3 MICE

5 TOXICITY/BIOMEDICAL EFFECTS (continued)

NON-HUMAN TOXICITY EXCERPTS - NTOX(2)-cont.

TREATED WITH VINYLIDENE CHLORIDE; NO SUCH TUMORS OCCURRED IN CONTROLS. 3 HEPATOMAS & 2 SKIN KERATOACANTHOMAS WERE ALSO REPORTED TO OCCUR IN TREATED MICE (LEE ET AL, 1977, 1978).
[IARC MONOGRAPHS. 1972-PRESENT V19 444 (1979)] ** UNREVIEWED **
****
Comment - KFG (ORNL) 09/03/87
IARC did not discuss the number of controls used in NTOX (2) or (3).
**********A

NON-HUMAN TOXICITY EXCERPTS - NTOX(3)

... GROUP OF 36 MALE & 36 FEMALE CD RATS WERE EXPOSED TO 220 MG/CU M (55 PPM) VINYLIDENE CHLORIDE IN AIR FOR 6 HR/DAY ON 5 DAYS/WK FOR UP TO 12 MO, @ WHICH TIME ... ALL SURVIVORS KILLED. 2 RATS DEVELOPED ANGIOSARCOMAS, 1 IN MESENTERIC LYMPH NODE & 1 IN SC TISSUE. NO SUCH TUMORS OCCURRED IN CONTROLS (LEE ET AL, 1977, 1978).
[IARC MONOGRAPHS. 1972-PRESENT V19 444 (1979)] ** PEER REVIEWED **

NON-HUMAN TOXICITY EXCERPTS - NTOX(4)

A GROUP OF 60 MALE & 60 16-WK-OLD FEMALE SPRAGUE-DAWLEY RATS WERE EXPOSED TO 800 MG/CU M REDUCED TO 600 MG/CU M (200 PPM REDUCED TO 150 PPM), AND 4 GROUPS OF 30 FEMALE & 30 MALE SPRAGUE-DAWLEY RATS OF THE SAME AGE WERE EXPOSED TO 40, 100, 200 OR 400 MG/CU M VINYLIDENE CHLORIDE IN AIR FOR 4 HR/DAY ON 4-5 DAYS/WK FOR 52 WK AND OBSERVED FOR UP TO 82 WK (TIME OF REPORTING). AN INCR INCIDENCE OF MAMMARY FIBROADENOMAS & CARCINOMAS (40-60%) WAS REPORTED, IN COMPARISON WITH 100 MALE & 100 FEMALE CONTROLS (32%), ALTHOUGH NO DOSE-RESPONSE RELATIONSHIP WAS FOUND. IN

ADDITION, ONE ZYMBAL GLAND CARCINOMA WAS SEEN IN ONE RAT TREATED WITH 100 PPM (MALTONI ET AL, 1977).
[IARC MONOGRAPHS. 1972-PRESENT

ORIGINAL (Red)

5 TOXICITY/BIOMEDICAL EFFECTS (continued)

NON-HUMAN TOXICITY EXCERPTS - NTOX(6)

INHALATION OF 2000 MG/CU M (500 PPM) VINYLIDENE CHLORIDE DURING 20 6-HR EXPOSURES CAUSED NASAL IRRITATION, REDUCED WT GAIN & INDUCTION OF HEPATIC HISTOPATHOLOGICAL CHANGES IN RATS.
[IARC MONOGRAPHS. 1972-PRESENT V19 445 (1979)] ** PEER REVIEWED **

NON-HUMAN TOXICITY EXCERPTS - NTOX(7)

RATS ... GIVEN VDC EITHER AS 200 MG/L IN DRINKING WATER OR AS 80-640 MG/CU M (20-160 PPM) BY INHALATION FOR 7 HR/DAY ON DAYS 6-15 OF GESTATION; RABBITS WERE GIVEN THE SAME DOSE BY INHALATION ON DAYS 6-18 OF GESTATION. NO TERATOGENIC EFFECT ... SEEN IN EITHER RATS OR RABBITS, ALTHOUGH SOME EVIDENCE OF EMBRYOTOXICITY & FETOTOXICITY WAS OBSERVED IN BOTH SPECIES ... EFFECTS WERE ASSOCIATED WITH MATERNALLY TOXIC LEVELS OF EXPOSURE.
[IARC MONOGRAPHS. 1972-PRESENT V19 446 (1979)] ** PEER REVIEWED **

NON-HUMAN TOXICITY EXCERPTS - NTOX(8)

SALMONELLA TYPHIMURIUM TA10A0 & TA1530 ... EXPOSED TO CONCENTRATIONS OF 2 & 20% (20,000 AND 200,0000 PPM) VINYALIDENE CHLORIDE IN AIR ... PRODUCED REVERSE MUTATIONS IN PRESENCE OF 9000 X GRAVITY SUPERNATANTS FROM LIVER, LUNG, & KIDNEY /CELLS/ OFMICE & RATS AND FROM ONE HUMAN LIVER BIOPSY SPECIMEN.
[IARC MONOGRAPHS. 1972-PRESENT V19 447 (1979)] ** UNREVIEWED **

NON-HUMAN TOXICITY EXCERPTS - NTOX(9)

AA

A

VINYLIDENE CHLORIDE WAS NOT MUTAGENIC IN THE DOMINANT LETHAL ATEST IN MALE CD-1 MICE EXPOSED BY INHALATION TO 40, 120 & 200, MG/CU M (10, 30, & 50 PPM) FOR 6 HR/DAY

FOR 5 DAYS.
[IARC MONOGRAPHS. 1972-PRESENT
V19 447 (1979)] ** PEER REVIEWED **

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NON-HUMAN TOXICITY EXCERPTS -
NTOX(10)

In an experiment still in progress at the time of reporting, groups of Swiss mice, 9 or 16 wk of age, were ex/posed for 4 hr/day on 4-5 days/wk to vinylidene chloride vapors in air at concn of 800, 400, 200, 100 or 40 mg/cu m (200, 100, 50, 25, or 10 ppm). Due to toxicity, mice treated wit
mal[illegible] ppm& (60 fe
emales) wer[illegible] for only

Occupational Health Guideline for 1,2-Dichloroethylene

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: ClCH=CHCl
- Synonyms: Acetylene dichloride; dioform; trans-acetylene dichloride; sym-dichloroethylene
- Appearance and odor: Colorless liquid with an ether-like, slightly acrid odor, like chloroform.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for 1,2-dichloroethylene is 200 parts of 1,2-dichloroethylene per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 790 milligrams of 1,2-dichloroethylene per cubic meter of air (mg/m³).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

1,2-Dichloroethylene can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- **Effects of overexposure**

Exposure to 1,2-dichloroethylene may cause dizziness, drowsiness, and unconsciousness.

- **Reporting signs and symptoms**

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to 1,2-dichloroethylene.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to 1,2-dichloroethylene at potentially hazardous levels:

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from 1,2-dichloroethylene exposure.

—Liver disease: Although 1,2-dichloroethylene is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of 1,2-dichloroethylene might cause exacerbation of symptoms due to its irritant properties.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

- **Summary of toxicology**

1,2-Dichloroethylene vapor is a narcotic and a mucous-membrane irritant. Variations in toxicity of the cis- as compared with the trans-form have been reported. A concentration of 39,000 ppm was lethal to guinea pigs, and narcosis was produced at 18,000 ppm. Dogs exposed to high concentrations of vapor developed superficial corneal turbidity which was reversible. No effects were observed in several species with repeated exposure for up to 6 months at 1000 ppm. It has been used as a general anesthetic in man; one industrial fatality was due to very high vapor inhalation in a small enclosure.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 96.9
2. Boiling point (760 mm Hg): 45 to 60 C (113 to 140 F)
3. Specific gravity (water = 1): 1.27
4. Vapor density (air = 1 at boiling point of 1,2-dichloroethylene): 3.34
5. Melting point: −49 to −81.5 C (−56 to −115 F)
6. Vapor pressure at 20 C (68 F): 180 to 265 mm Hg

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7. Solubility in water, g/100 g water at 20 C (68 F): 0.35 to 0.63

8. Evaporation rate (butyl acetate = 1): Data not available

• **Reactivity**

1. Conditions contributing to instability: Heat.

2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, phosgene, and carbon monoxide) may be released in a fire involving 1,2-dichloroethylene.

4. Special precautions: 1,2-Dichloroethylene will attack some forms of plastics, rubber, and coatings.

• **Flammability**

1. Flash point: 2.2 to 3.9 C (36 to 39 F) (closed cup)

2. Autoignition temperature: 460 C (860 F) for trans-1,2-dichloroethylene

3. Flammable limits in air, % by volume: Lower: 9.7; Upper: 12.8

4. Extinguishant: Dry chemical, foam, carbon dioxide

• **Warning properties**

May reports an odor threshold of 0.085 ppm for dichloroethylene. For the purposes of this guideline, 1,2-dichloroethylene is treated as a material with adequate warning properties.

1,2-Dichloroethylene is an eye irritant, according to Grant, but the concentrations at which irritation occurs are not mentioned.

MONITORING AND MEASUREMENT PROCEDURES

• **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Method**

Sampling and analyses may be performed by collection of 1,2-dichloroethylene vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure 1,2-dichloroethylene may be used. An analytical method for 1,2-dichloroethylene is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid 1,2-dichloroethylene.

• Clothing wet with liquid 1,2-dichloroethylene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of 1,2-dichloroethylene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the 1,2-dichloroethylene, the person performing the operation should be informed of 1,2-dichloroethylene's hazardous properties.

• Any clothing which becomes wet with liquid 1,2-dichloroethylene should be removed immediately and not reworn until the 1,2-dichloroethylene is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where liquid 1,2-dichloroethylene may contact the eyes.

SANITATION

• Skin that becomes wet with liquid 1,2-dichloroethylene should be promptly washed or showered with soap or mild detergent and water to remove any 1,2-dichloroethylene.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to 1,2-dichloroethylene may occur and control methods which may be effective in each case:

Operation	Controls
Use as a low-temperature solvent for heat-sensitive substances in extraction of caffeine, perfume oils, and fats from flesh of animals	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in rubber and dye industries in extraction and application	Process enclosure; local exhaust ventilation; personal protective equipment
Use as a direct solvent in gums, waxes, oils, camphor, and phenol; use in solvent mixtures for esters and ether derivatives, lacquers, resins, thermoplastics, and artificial fibers	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in organic synthesis for polymers and telomers	Process enclosure; local exhaust ventilation; personal protective equipment
Use in miscellaneous applications as liquid dry cleaning agent, cleaning solution for printed circuit boards, food packaging adhesives, and germicidal fumigants	General dilution ventilation; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If 1,2-dichloroethylene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If 1,2-dichloroethylene gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If 1,2-dichloroethylene soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

- **Breathing**

If a person breathes in large amounts of 1,2-dichloroethylene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- **Swallowing**

When 1,2-dichloroethylene has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

- **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If 1,2-dichloroethylene is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. 1,2-Dichloroethylene should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of 1,2-dichloroethylene vapors are permitted.

- Waste disposal method:

1,2-Dichloroethylene may be disposed of by atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

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RESPIRATORY PROTECTION FOR 1,2-DICHLOROETHYLENE

Condition	Minimum Respiratory Protection* Required Above 200 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
4000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 4000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Ethyl Benzene

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $C_2H_5C_6H_5$
- Synonyms: Phenylethane; ethylbenzol
- Appearance and odor: Colorless liquid with an aromatic odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for ethyl benzene is 100 parts of ethyl benzene per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 435 milligrams of ethyl benzene per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Ethyl benzene can affect the body if it is inhaled, is swallowed, or comes in contact with the eyes or skin.

- **Effects of overexposure**

1. Short-term Exposure: Ethyl benzene causes irritation of the eyes, nose, throat, and skin. With exposure to high concentrations, irritating effects are more pronounced, and a person may begin to feel weak, dizzy, drowsy, and become unconscious.

2. Long-term Exposure: Prolonged or repeated ethyl benzene exposure of the skin may casue skin rash.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to ethyl benzene.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to ethyl benzene at potentially hazardous levels:

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from ethyl benzene exposure.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of ethyl benzene might cause exacerbation of symptoms due to its irritant properties or psychic reflex bronchospasm.

—Kidney disease: Although ethyl benzene is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with possible impairment of renal function.

—Liver disease: Although ethyl benzene is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Skin disease: Ethyl benzene is a defatting agent and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

- **Summary of toxicology**

Ethyl benzene is primarily an irritant of skin and, to some degree, of eyes and upper respiratory tract. Systemic absorption causes depression of the central nervous system with narcosis at very high concentrations. Aspiration of small amounts causes extensive edema and hemorrhage of lung tissue. It is readily metabolized and excreted chiefly as mandelic acid in the urine.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 106
  2. Boiling point (760 mm Hg): 136 C (277 F)
  3. Specific gravity (water = 1): 0.865
  4. Vapor density (air = 1 at boiling point of ethyl benzene): 3.66
  5. Melting point: −95 C (−139 F)
  6. Vapor pressure at 20 C (68 F): 7.1 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): 0.015
  8. Evaporation rate (butyl acetate = 1): Less than 1
- **Reactivity**
  1. Conditions contributing to instability: Heat
  2. Incompatibilities: Contact with strong oxidizing agents may cause fires and explosions.
  3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving ethyl benzene.
  4. Special precautions: None
- **Flammability**
  1. Flash point: 15 C (59 F) (closed cup)
  2. Autoignition temperature: 432 C (810 F)
  3. Flammable limits in air, % by volume: Lower: 1.0; Upper: 6.7
  4. Extinguishant: Dry chemical, foam, or carbon dioxide
- **Warning properties**
  1. Odor Threshold: According to the Department of Transportation's *CHRIS Hazardous Chemical Data,*, ethyl benzene has an odor threshold of 140 ppm.
  2. Eye Irritation Level: According to the AIHA *Hygienic Guide*, "the vapor caused a noticeable eye irritation in humans at concentrations of 200 ppm."
  3. Evaluation of Warning Properties: Through its odor and irritant effects, ethyl benzene can be detected at a concentration less than twice the permissible exposure limit. Therefore, for the purposes of this guideline, ethyl benzene is treated as a material with adequate warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

Sampling and analyses may be performed by collection of ethyl benzene vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure ethyl benzene may be used. An analytical method for ethyl benzene is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid ethyl benzene.
- Clothing wet with liquid ethyl benzene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of ethyl benzene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the ethyl benzene, the person performing the operation should be informed of ethyl benzene's hazardous properties.
- Non-impervious clothing which becomes contaminated with liquid ethyl benzene should be removed promptly and not reworn until the ethyl benzene is removed from the clothing.
- Any clothing which becomes wet with liquid ethyl benzene should be removed immediately and not reworn until the ethyl benzene is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid ethyl benzene may contact the eyes.

SANITATION

• Skin that becomes contaminated with liquid ethyl benzene should be promptly washed or showered with soap or mild detergent and water to remove any ethyl benzene.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to ethyl benzene may occur and control methods which may be effective in each case:

Operation	Controls
Liberation during manufacture of styrene monomer	Local exhaust ventilation
Use during spray application of vinyl resin surface coating	Local exhaust ventilation; personal protective equipment
Liberation during manufacture of paints, varnishes, and other surface coatings	Local exhaust ventilation; general dilution ventilation
Use in manufacture and application of rubber adhesives	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use during electroplating of aluminum on copper or steel	Local exhaust ventilation for open-surface tanks
Liberation during oven baking and drying of surface coatings	Local exhaust ventilation for ovens
Liberation during application of surface coatings by dipping, flow coatings, and roller coating	Local exhaust ventilation
Liberation during use as an intermediate in dye manufacture	General dilution ventilation
Use as a heat-transfer medium; use as a dielectric	General dilution ventilation; personal protective equipment
Liberation during production of acetophenone by oxidation of ethyl benzene	General dilution ventilation

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If ethyl benzene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If ethyl benzene gets on the skin, promptly flush the contaminated skin with water. If ethyl benzene soaks through the clothing, remove the clothing immediately and flush the skin with water. When there is skin irritation, get medical attention.

• **Breathing**

If a person breathes in large amounts of ethyl benzene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

If ethyl benzene has been swallowed, do not induce vomiting. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If ethyl benzene is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber. Combustion may be improved by mixing with a more flammable liquid. Ethyl benzene should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.

• Waste disposal methods:

Ethyl benzene may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.

2. By atomizing in a suitable combustion chamber. Combustion may be improved by mixing with a more flammable liquid.

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RESPIRATORY PROTECTION FOR ETHYL BENZENE

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
2000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 2000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Isopropyl Alcohol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $CH_3CHOHCH_3$
- Synonyms: Isopropanol; IPA; 2-propanol; sec-propyl alcohol
- Appearance and odor: Colorless liquid with an odor of rubbing alcohol.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for isopropyl alcohol is 400 parts of isopropyl alcohol per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 980 milligrams of isopropyl alcohol per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 400 ppm averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 800 ppm averaged over a 15-minute period. The NIOSH Criteria Document for Isopropyl Alcohol should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Isopropyl alcohol can affect the body if it is swallowed, is inhaled, or comes in contact with the skin or eyes.

- **Effects of overexposure**

1. Short-term Exposure: Exposure to high air concentrations of isopropyl alcohol may cause mild irritation of the eyes, nose, and throat. Drowsiness, headache, and incoordination may also occur. Swallowing isopropyl alcohol may cause drowsiness, unconsciousness, and death. Gastrointestinal pain, cramps, nausea, vomiting, and diarrhea may also result from swallowing this alcohol.

2. Long-term Exposure: Drying and cracking of the skin may result from prolonged skin exposure. Epidemiological investigations have established that a carcinogenic substance is present in isopropyl alcohol manufacturing areas, but have not confirmed isopropyl alcohol as a causative agent of cancer.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to isopropyl alcohol.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to isopropyl alcohol at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the employee at increased risk, and to establish a baseline for future health monitoring. Examination of the skin, liver, kidneys, and respiratory system should be stressed.

—Skin disease: Isopropyl alcohol is a defatting agent and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver disease: Although isopropyl alcohol is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Kidney disease: Although isopropyl alcohol is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of isopropyl

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alcohol might cause exacerbation of symptoms due to its irritant properties.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• **Summary of toxicology**

The most important toxic effect of isopropyl alcohol is narcosis, which occurs in mice at vapor concentrations of 3000 ppm, the effects increasing with the duration of exposure. Exposure to higher concentrations results in ataxia, followed by deep narcosis and death. Reversible changes occurred in the liver fat of mice repeatedly exposed to high concentrations of vapor. Isopropyl alcohol is metabolized fairly rapidly, and acetone may be detected in the urine following heavy exposures. Human volunteers reported mild irritation of the eyes, nose, and throat after 3 to 5 minutes exposure to vapor at 400 ppm; at 800 ppm the results were not severe, but most subjects found the atmosphere to be objectionable. Accidental, extensive wetting of the skin could occur in industrial situations and as isopropyl alcohol is absorbed readily through the skin, the additive effect of inhalation and skin absorption could have serious results. Similarly, there is a risk of deliberate ingestion of isopropyl alcohol as a substitute for ethyl alcohol, which would add to the effects of inhalation. The defatting action of isopropyl alcohol can cause mild skin irritation, but a small percentage of workers may develop contact dermatitis of a more serious nature. No chronic systemic effects have been reported in humans.

CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data**

1. Molecular weight: 60
2. Boiling point (760 mm Hg): 82 C (180 F)
3. Specific gravity (water = 1): 0.78
4. Vapor density (air = 1 at boiling point of isopropyl alcohol): 2.1
5. Melting point: −89 C (−128 F)
6. Vapor pressure at 20 C (68 F): 33 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Miscible in all proportions
8. Evaporation rate (butyl acetate = 1): 2.83

• **Reactivity**

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving isopropyl alcohol.
4. Special precautions: Isopropyl alcohol will attack some forms of plastics, rubber, and coatings. It may also react with metallic aluminum at high temperatures.

• **Flammability**

1. Flash point: 12 C (53 F) (closed cup)
2. Autoignition temperature: 399 C (750 F)
3. Flammable limits in air, % by volume: Lower: 2.0; Upper: 12.0
4. Extinguishant: Alcohol foam, dry chemical, carbon dioxide

• **Warning properties**

1. Odor Threshold: Patty reports, "Scherberger et al. stated that the concentration with identifiable odor of isopropyl alcohol is 200 ppm." May reports an odor threshold of 45 ppm.
2. Irritation Level: According to Patty, "mild irritation of the eyes, nose, and throat was induced in human subjects exposed by Nelson and associates for 3 to 5 minutes to 400 ppm of isopropyl alcohol."
3. Evaluation of Warning Properties: Through its odor and irritant effects, isopropyl alcohol can be detected below or at the permissible exposure limit. For the purposes of this guideline, therefore, it is treated as a material with adequate warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of isopropyl alcohol. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• **Method**

Sampling and analyses may be performed by collection of isopropyl alcohol vapors using an adsorption tube with subsequent desorption with 2-butanol in carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure isopropyl alcohol may be used. An analytical method for isopropyl alcohol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental

concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid isopropyl alcohol.

• Any clothing which becomes wet with liquid isopropyl alcohol should be removed immediately and not reworn until the isopropyl alcohol is removed from the clothing.

• Clothing wet with liquid isopropyl alcohol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of isopropyl alcohol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the isopropyl alcohol, the person performing the operation should be informed of isopropyl alcohol's hazardous properties.

• Employees should be provided with and required to use splash-proof safety goggles where liquid isopropyl alcohol may contact the eyes.

SANITATION

• Skin that becomes wet with liquid isopropyl alcohol should be promptly washed or showered to remove any isopropyl alcohol.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to isopropyl alcohol may occur and control methods which may be effective in each case:

Operation	Controls
Use as a solvent in spray and heat applications of surface coatings, including stain, varnish, nitrocellulose lacquers, and quick-drying inks and paints	General dilution ventilation; personal protective equipment
Use as a solvent in application other than spray or heat of surface coatings, including stain, varnish, nitrocellulose lacquers, quick-drying inks and paints, textile coatings and dyes, dopes, and polishes	General dilution ventilation; personal protective equipment
Use in manufacture and liberation during packing of acetone	General dilution ventilation; personal protective equipment
Use as a solvent in manufacture of surface coatings and thinners	General dilution ventilation; personal protective equipment
Use in organic synthesis for isopropyl derivatives, including phenols, acetates, xanthates, ether, amines, myristate, palmitate, nitrite, and glycerin	General dilution ventilation; personal protective equipment
Use in manufacture of cosmetics, including liniments, skin lotions, permanent wave lotions, and color hair rinses	General dilution ventilation; personal protective equipment
Liberation during use as a disinfectant and sanitizer; use during cleaning and degreasing operations	General dilution ventilation; personal protective equipment
Use in preparation, manufacture, and packaging of disinfectants and sanitizers, including rubbing alcohol, other antiseptic solutions, skin astringents, mouth washes, and medicated sprays	General dilution ventilation; personal protective equipment

Operation	Controls
Use in manufacture of cleaning and degreasing agents, including stain and spot removers, glass cleaners, rug and uphostery cleaning, tar remover, liquid soap, and windshield cleaner fluid; use in manufacture of de-icing, de-fogging, and anti-freeze products	General dilution ventilation; personal protective equipment
Use in extraction and purification of alkaloids, proteins, chlorophyll, perfumes, sulfuric acid, vitamins, kelp, pectin, resins, gums, and waxes	General dilution ventilation; personal protective equipment
Use in manufacture of rubber products; use as an additive in anti-stalling gasoline, lubricants, denatured ethyl alcohol, hydraulic brake fluids, and rocket fuel	General dilution ventilation; personal protective equipment
Use in manufacture of adhesives, including nitrocellulose film and microfilm cement; use in manufacture of safety glass	General dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If isopropyl alcohol gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If isopropyl alcohol gets on the skin, flush the contaminated skin with water. If isopropyl alcohol soaks through the clothing, remove the clothing immediately and flush the skin with water. If there is skin irritation, get medical attention.

• **Breathing**

If a person breathes in large amounts of isopropyl alcohol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When isopropyl alcohol has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If isopropyl alcohol is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber. Isopropyl alcohol should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.

• Waste disposal methods:

Isopropyl alcohol may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber.

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RESPIRATORY PROTECTION FOR ISOPROPYL ALCOHOL

Condition	Minimum Respiratory Protection* Required Above 400 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
5000 ppm or less	A gas mask with a chin-style organic vapor canister.
20,000 ppm or less	A gas mask with a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 20,000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR INORGANIC LEAD

INTRODUCTION

"Inorganic lead" is defined as lead oxides, metallic lead, and lead salts (including organic salts such as lead soaps but excluding lead arsenate). This guideline summarizes pertinent information about inorganic lead for workers, employers, and occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

- **Formula:** Pb
- **Synonyms:** C.I. pigment metal 4, C.I. 77575, KS-4, lead flake, lead S2
- **Identifiers:** CAS 7439-92-1; RTECS OF7525000; DOT 1794
- **Appearance and odor:** Bluish-white, silvery, or gray odorless solid

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 207.19
2. Boiling point (at 760 mmHg): 1,740°C (3,164°F)
3. Specific gravity (water = 1): 11.34
4. Melting point: 327.5°C (621.5°F)
5. Insoluble in water

- **Reactivity**

1. Incompatibilities: Lead reacts vigorously with oxidizing materials. Contact with hydrogen peroxide or active metals such as sodium or potassium may cause fires or explosions.
2. Hazardous decomposition products: Toxic fumes (e.g., lead oxide) may be released in a fire involving inorganic lead.

- **Flammability**

1. Extinguishant: Dry sand, dry dolomite, or dry graphite
2. Caution: Lead is combustible in powder form when exposed to heat or flame

- **Warning properties**

Evaluation of warning properties for respirator selection: Based on lack of information on odor threshold and eye irritation levels, inorganic lead should be treated as a chemical with poor warning properties.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for inorganic lead is 50 micrograms of lead per cubic meter of air ($\mu g/m^3$) as a time-weighted average (TWA) concentration over an 8-hour workshift. If a worker is exposed to lead for more than 8 hours in any workday, the PEL, as a TWA for that day, shall be reduced according to the following formula: maximum permissible limit (in $\mu g/m^3$) = 400 divided by hours worked in the day. The National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL) is 100 $\mu g/m^3$ as a TWA for up to a 10-hour workshift, 40-hr. workweek. The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV®) is 0.15 mg/m^3 (150 $\mu g/m^3$) as a TWA for a normal 8-hour workday and a 40-hour workweek (Table 1).

Table 1.—Occupational exposure limits for inorganic lead

	Exposure units $\mu g/m^3$
OSHA PEL TWA	50
NIOSH REL TWA	100*
ACGIH TLV® TWA	150

* Air level to be maintained such that worker blood lead remains ≤ 60 $\mu g/100g$.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Inorganic lead may cause adverse health effects following exposure via inhalation or ingestion.

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• **Summary of toxicology**

1. *Effects on animals:* In rats or mice, chronic oral administration or subcutaneous or intraperitoneal injection of lead subacetate, lead acetate, or lead phosphate produced cancer of the kidneys. Intravenous or intraperitoneal injection of lead nitrate, lead acetate, or lead chloride to pregnant mice, rats, or hamsters caused increased fetal mortality and malformations of the posterior extremities and urogenital and intestinal tracts in the offspring.

2. *Effects on humans:* Inhalation or ingestion of inorganic lead has caused peripheral neuropathy with paralysis of the muscles of the wrists and ankles, encephalopathy, anemia (due to decreased red blood cell life and impaired heme synthesis), proximal kidney tubule damage, decreased kidney function, and chronic kidney disease. Lead can accumulate in the soft tissues and bones, with the highest accumulation in the liver and kidneys, and elimination is slow. Lead can penetrate the placental barrier, resulting in neurologic disorders in infants.

• **Signs and symptoms of exposure**

1. *Short-term (acute):* Exposure to inorganic lead can cause decreased appetite, insomnia, headache, muscle and joint pain, colic, and constipation.

2. *Long-term (chronic):* Exposure to inorganic lead can cause weakness, weight loss, nausea, vomiting, constipation, blue or blue-black dot-like pigmentation on the gums ("lead line"), severe headache and abdominal cramps, delirium, convulsions, and coma.

RECOMMENDED MEDICAL PRACTICES

• **Medical surveillance program**

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, morbidity, and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• **Preplacement medical evaluation**

Prior to placing a worker in a job with a potential for exposure to inorganic lead, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the kidneys and the hematopoietic (blood cell forming), nervous, gastrointestinal, and reproductive systems.

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to inorganic lead at or below the NIOSH REL.

The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include preexisting neuromuscular disease. In addition to the medical interview and physical examination, the physician should consider obtaining additional baseline electrophysiologic and electromyographic studies and an assessment of fertility, using standardized methods and evaluation criteria. The physician should also obtain baseline values for the complete blood count including the reticulocyte count and for those tests which characterize prior internal exposure (e.g., blood lead level) and the effects of prior exposures (e.g., erythrocyte zinc protoporphyrin and delta-aminolevulinic acid dehydrogenase).

• **Periodic medical screening and/or biologic monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to inorganic lead. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the physiologic function of the kidneys and the hematopoietic (blood cell forming), nervous, gastrointestinal, and reproductive systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population. The following tests should be used and interpreted according to standardized epidemiologic procedures and evaluation criteria: a complete blood count with reticulocyte count and those tests which characterize prior internal exposure (e.g., blood lead level) and the effects of exposures (e.g., erythrocyte zinc protoporphyrin and delta-aminolevulinic acid dehydrogenase).

• **Medical practices recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population. Because occupational exposure to inorganic lead may cause adverse reproductive effects and diseases of prolonged induction-

latency, the need for medical surveillance may extend well beyond termination of employment.

• **Sentinel health events**

1. Acute SHE's include: Acute renal failure.
2. Delayed-onset or reproductive SHE's include: Inflammatory and toxic neuropathy and chronic renal failure.

MONITORING AND MEASUREMENT PROCEDURES

• **TWA exposure evaluation**

Measurements to determine worker exposure to inorganic lead should be taken so that the TWA exposure is based on a single entire workshift sample or an appropriate number of consecutive samples collected during the entire workshift. Under certain conditions, it may be appropriate to collect several short-term interval samples (up to 30 minutes each) to determine the average exposure level. Air samples should be taken in the worker's breathing zone (air that most nearly represents that inhaled by the worker).

• **Method**

Sampling and analysis may be performed by collecting inorganic lead with cellulose membrane filters followed by acid digestion and analysis by atomic absorption. A detailed sampling and analytical method for inorganic lead may be found in the *NIOSH Manual of Analytical Methods* (method number 7082).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, face shields (8-inch minimum) and other appropriate protective clothing necessary to prevent skin contact with inorganic lead.

Workers should be provided with and required to use dust-proof safety goggles where inorganic lead may come in contact with the eyes.

SANITATION

Clothing which is contaminated with inorganic lead should be removed immediately and placed in closed containers for storage until it can be discarded or until provision is made for the removal of inorganic lead from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of inorganic lead's hazardous properties.

Change and shower rooms should be provided with separate locker facilities for street and work clothes.

Skin that becomes contaminated with inorganic lead should be promptly washed with soap and water.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or application of cosmetics, the storage or smoking of tobacco or other smoking materials, or the storage or use of products for chewing should be prohibited in work areas.

Workers who handle inorganic lead should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to inorganic lead may occur and control methods which may be effective in each case are listed in Table 2.

Table 2.—Operations and methods of control for inorganic lead

Operations	Controls
During primary (ore) and secondary (scrap) smelting of lead; during the manufacture of storage batteries; during typecasting and remelting of type metal in printing	Process enclosure, local exhaust ventilation, dust control, personal protective equipment
During soldering in the fabrication of metal articles	Process enclosure, local exhaust ventilation, personal protective equipment
During melting and pouring of lead and alloys containing lead; during welding, burning, and cutting of metal structures containing lead or painted with lead containing surface coatings	Local exhaust ventilation, personal protective equipment
During the use of lead in the manufacture of surface coatings, including paints and varnishes; during the manufacture of ceramics and glass	Local exhaust ventilation, personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures.

• **Eye exposure**

Where there is any possibility of a worker's eyes being exposed to inorganic lead, an eye-wash fountain should be provided within the immediate work area for emergency use.

If inorganic lead gets into the eyes, flush them immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this compound.

• **Skin exposure**

Where there is any possibility of a worker's body being exposed to inorganic lead, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If inorganic lead gets on the skin, wash it immediately with soap and water. If inorganic lead penetrates the clothing, remove the clothing immediately and wash the skin with soap and water. Get medical attention promptly.

• **Rescue**

If a worker has been incapacitated, move the affected worker from the hazardous exposure. Put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILLS AND LEAKS

Workers not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

If inorganic lead is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities of liquids containing inorganic lead, absorb on paper towels and place in an appropriate container.
4. Large quantities of liquids containing inorganic lead may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container.
5. If in solid form, inorganic lead may be collected and placed in an appropriate container.
6. Inorganic lead may be collected by vacuuming with an appropriate system.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

For each level of respirator protection, only those respirators that have the minimum required protection factor and meet other use restrictions are listed. All respirators that have higher protection factors may also be used.

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Table 3.—Respiratory protection for inorganic lead

Condition	Minimum respiratory protection*†
Concentration:	
Less than or equal to 0.5 mg/m³	Any supplied air respirator
	Any air-purifying respirator with a high-efficiency particulate filter
	Any self-contained breathing apparatus
Less than or equal to 1.25 mg/m³	Any powered air-purifying respirator with a high-efficiency particulate filter
	Any supplied-air respirator operated in a continuous flow mode
Less than or equal to 2.5 mg/m³	Any air-purifying full facepiece respirator with a high-efficiency particulate filter
	Any powered air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter
	Any self-contained breathing apparatus with a full facepiece
	Any supplied-air respirator with a full facepiece
	Any supplied-air respirator with a tight-fitting facepiece and operated in a continuous flow mode
Less than or equal to 50 mg/m³	Any supplied-air respirator with a half-mask and operated in a pressure-demand or other positive pressure mode
Less than or equal to 100 mg/m³	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown concentrations or levels above 100 mg/m³	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator with a high-efficiency particulate filter
	Any appropriate escape-type self-contained breathing apparatus

* Only NIOSH/MSHA-approved equipment should be used.
† The respiratory protection listed for any given condition is the minimum required to meet the NIOSH REL of 100 μg/m³ (TWA).

Occupational Health Guideline for Methyl Chloride

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: CH_3Cl
- Synonyms: Chloromethane
- Appearance and odor: Colorless gas with a faint, sweet odor that is not noticeable at dangerous concentrations.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for methyl chloride is 100 parts of methyl chloride per million parts of air (ppm) averaged over an eight-hour work shift, with a ceiling level of 200 ppm and a maximum acceptable peak of 300 ppm for 5 minutes in any three-hour period. The American Conference of Governmental Industrial Hygienists has issued a Notice of Intended Changes of its recommended Threshold Limit Value for methyl chloride from 100 ppm to 50 ppm.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Methyl chloride can affect the body if it is inhaled or if it comes in contact with the eyes or skin.

- **Effects of overexposure**

1. Short-term Exposure: Deaths have occurred following single severe or repeated prolonged moderate overexposure. Overexposure may cause dizziness, vomiting, abdominal pain, diarrhea, breathing difficulties, and unconsciousness. Convulsions and disturbances of vision may occur. It may also damage the kidneys, liver, or blood. The symptoms of methyl chloride overexposure are usually delayed in onset. Frostbite may occur from contact with liquefied methyl chloride.

2. Long-term Exposure: Repeated moderate or mild overexposure may cause delayed (24 to 48 hours) onset of dizziness, headache, mental confusion, slurred speech, double vision, and sleepiness. Recovery from the effects of exposure to this chemical may be slow.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to methyl chloride.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to methyl chloride at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the central nervous system, liver, and kidneys should be stressed.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

Methyl chloride vapor is a narcotic and may cause a toxic encephalopathy. The LC50 for mice for 7-hour exposure was approximately 3000 ppm. At this concentration some species showed pulmonary edema with hemorrhage, moderate centrolobular necrosis of the liver, and tubular damage in the kidney. At 500 ppm repeated daily for 6 hours, there was response in some species, while 300 ppm daily for 64 weeks produced no detectable effects. Human fatalities have occurred from a single severe exposure or less severe prolonged exposures. Severe but nonfatal poisoning in man is characterized by a latent period of several hours, followed by dizziness, nausea, vomiting, double vision, weakness, paralysis, convulsions, and coma; renal or hepatic

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These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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damage and anemia also occur. Some workers exposed daily to concentrations averaging 195 to 475 ppm showed delayed signs, including weakness, drowsiness, staggering gait, slurred speech, lapses of memory, and cyanosis. The onset is often insidious and may be confused with mild viral illness; more severe intoxication has been mistaken for viral encephalitis or heavy-metal poisoning. Effects may last for a long period following exposure. No effects were seen in other workers exposed to 15 to 195 ppm. Frostbite may result from contact with the liquid.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 50.5
2. Boiling point (760 mm Hg): −24.2 C (−11.6 F)
3. Specific gravity (water = 1): 0.92 (liquid)
4. Vapor density (air = 1 at boiling point of methyl chloride): 1.8
5. Melting point: −97.6 C (−144 F)
6. Vapor pressure at 20 C (68 F): 4.8 atm.
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Reactivity**

1. Conditions contributing to instability: Heat, especially when in contact with water or metals such as aluminum, magnesium, and zinc.
2. Incompatibilities: Contact with chemically active metals such as potassium, powdered aluminum, magnesium, and zinc will cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride and carbon monoxide) may be released in a fire involving methyl chloride.
4. Special precautions: Methyl chloride will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Flash point: Not pertinent (gas)
2. Autoignition temperature: 632 C (1170 F)
3. Flammable limits in air, % by volume: Lower: 7.6; Upper: 19
4. Extinguishant: Stop flow of gas.

- **Warning properties**

May reports an odor threshold of 10 ppm. However, Patty states that methyl chloride has no odor or other warning properties, and Jacobs states that methyl chloride does not have adequate warning properties at higher concentrations.

Methyl chloride is not an eye irritant, according to Grant, even in concentrations which are "dangerously toxic."

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of methyl chloride. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Peak Above Ceiling Evaluation**

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of methyl chloride. Each measurement should consist of a 5-minute sample or a series of consecutive samples totalling 5 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

Sampling and analyses may be performed by collection of methyl chloride on activated carbon, followed by desorption with methanol and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure methyl chloride may be used. An analytical method for methyl chloride is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 4, 1978, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00317-3).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted

are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent the skin from becoming wet with liquid methyl chloride or from becoming frozen from contact with vessels containing methyl chloride.

• Any clothing which becomes wet with liquid methyl chloride should be removed immediately and not reworn until the methyl chloride has evaporated.

• Employees should be provided with and required to use splash-proof safety goggles where liquid methyl chloride may contact the eyes.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to methyl chloride may occur and control methods which may be effective in each case:

Operation	Controls
Use in manufacture of silicone resins, and tetramethyl lead; use as a methylating and chlorinating agent; use as a dewaxing agent in petroleum refining; use as a catalyst solvent in production of butyl rubber	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of a variety of other compounds; as an extractant for greases, oils, and resins	Process enclosure; local exhaust ventilation; personal protective equipment
Liberation during use as a foaming agent in production of plastics; in the manufacture and application of pesticides, pharmaceuticals, and perfumes; as a propellant in aerosols; and use as a refrigerant	Process enclosure; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If liquefied methyl chloride gets into the eyes, wash eyes immediately with large amounts of water. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If liquefied methyl chloride gets on the skin, immediately flush the contaminated skin using soap or mild detergent and water if the methyl chloride has not already evaporated. If liquefied methyl chloride soaks through the clothing, remove the clothing immediately and flush the skin using soap or mild detergent and water. Do not use hot water for skin flushing. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of methyl chloride, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

LEAK AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of leaks until cleanup has been completed.

• If methyl chloride is leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of leak.
3. Stop flow of gas.

• Waste disposal method:

Methyl chloride may be disposed of by burning in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

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RESPIRATORY PROTECTION FOR METHYL CHLORIDE

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
1000 ppm or less	Any supplied-air respirator. Any self-contained breathing apparatus.
5000 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
10,000 ppm or less	A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.
Greater than 10,000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Methylene Chloride

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: CH_2Cl_2
- Synonyms: Dichloromethane; methylene dichloride
- Appearance and odor: Colorless liquid with an odor like chloroform.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for methylene chloride is 500 parts of methylene chloride per million parts of air (ppm) averaged over an eight-hour work shift, with an acceptable ceiling level of 1000 ppm and a maximum peak concentration of 2000 ppm for 5 minutes in any two-hour period. NIOSH has recommended that the permissible exposure limit be reduced to 75 ppm averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling level of 500 ppm averaged over a 15-minute period. NIOSH further recommends that permissible levels of methylene chloride be reduced where carbon monoxide is present. The NIOSH Criteria Document for Methylene Chloride should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Methylene chloride can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- **Effects of overexposure**

1. Short-term Exposure: Methylene chloride is an anesthetic. Inhaling the vapor may cause mental confusion, light-headedness, nausea, vomiting, and headache. Continued exposure may cause increased light-headedness, staggering, unconsciousness, and death. High vapor concentrations may also cause irritation of the eyes and respiratory tract. Exposure to this chemical may make the symptoms of angina worse. Skin exposure to the liquid may cause irritation. If the liquid is held in contact with the skin, it may cause skin burns. Splashes of the liquid into the eyes may cause irritation.

2. Long-term Exposure: Prolonged or repeated exposure to methylene chloride may cause irritation of the skin.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to methylene chloride.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to methylene chloride at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the employee at increased risk, and to establish a baseline for future health monitoring. Examination of the skin, liver, kidneys, cardiovascular system, and blood should be stressed. Clinical impressions of the autonomic nervous system and pulmonary function should be made, with additional tests conducted where indicated.

—Skin disease: Methylene chloride can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver function test: Methylene chloride causes liver damage in animals and this justifies consideration before exposing persons with impaired liver function. A profile of liver function should be obtained by utilizing a medically acceptable array of biochemical tests.

—Kidney disease: Methylene chloride causes kidney damage in animals and this justifies special considera-

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These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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tion before exposing persons with impaired renal function.

—Cardiovascular disease: Because of reports of excessive carbon monoxide levels following exposure to methylene chloride, persons with cardiac disease may be at increased risk.

—A complete blood count: A complete blood count should be performed, including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit. Carboxyhemoglobin values should also be determined periodically, and any level above 5% should prompt an investigation of the worker and his workplace.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• **Summary of toxicology**

Methylene chloride vapor is a mild narcotic. Exposure of animals to 15,000 ppm for 7 hours was fatal. Animal experiments have shown that continuous exposure to 1,000 ppm can be lethal in 5 to 7 weeks for dogs and that fatty livers, icterus, pneumonia, and splenic atrophy developed in dogs. Cardiac arrhytmias attributed to sensitization of the myocardium have been observed following exposure to high concentrations of some chlorinated hydrocarbons, but dogs exposed to 10,000 and 20,000 ppm of methylene chloride did not show this phenomenon. In human experiments, inhalation of 500 to 1000 ppm for 1 to 2 hours resulted in lightheadedness; there was sustained elevation of carboxyhemoglobin level. High exposures have resulted in deaths in industrial situations. Lower but unknown concentrations have caused such symptoms as lightheadedness, weakness, nausea, and "drunken behavior," resulting in mistakes and accidental falls. Phosgene poisoning has been reported to occur in several cases where methylene chloride was used in the presence of an open fire. Liquid methylene chloride is irritating to the skin on repeated contact. Splashed in the eye, it is painfully irritating, but is not likely to cause serious injury.

CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data**

1. Molecular weight: 84.9
2. Boiling point (760 mm Hg): 39.8 C (104 F)
3. Specific gravity (water = 1): 1.3
4. Vapor density (air = 1 at boiling point of methylene chloride): 2.9
5. Melting point: −97 C (−142 F)
6. Vapor pressure at 20 C (68 F): 350 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 1.32
8. Evaporation rate (butyl acetate = 1): 27.5

• **Reactivity**

1. Conditions contributing to instability: Heat and moisture
2. Incompatibilities: Contact with strong oxidizers, strong caustics, and chemically active metals such as aluminum or magnesium powder, sodium and potassium may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, phosgene, and carbon monoxide) may be released in a fire involving methylene chloride.
4. Special precautions: Liquid methylene chloride will attack some forms of plastics, rubber, and coatings.

• **Flammability**

1. Flash point: None with normal test method
2. Autoignition temperature: 556 C (1033 F)
3. Flammable limits in air, % by volume: (at elevated temperatures) Lower: 12; Upper: 19
4. Extinguishant: Dry chemical, carbon dioxide, foam

• **Warning properties**

1. Odor Threshold: Different authors have reported varying odor thresholds for methylene chloride. Summer and May both report 150 ppm; Kirk-Othmer and Sax both report 25 to 50 ppm; Spector reports 320 ppm. Patty, however, states that since one can become adapted to the odor, it cannot be considered an adequate warning property.
2. Eye Irritation Level: Grant reports that methylene chloride "presents no particular hazard to the eyes." Kirk-Othmer, however, reports that "methylene chloride vapor is seriously damaging to the eyes." Sax agrees with Kirk-Othmer's statement.

The *Documentation of TLV's* states that irritation of the eyes has been observed in workers who had been exposed to concentrations up to 5000 ppm, but that neurasthenic disorders were found in 50% and digestive disturbances in 30% of the persons exposed.

3. Other Information: Gleason reports that methylene chloride may be "irritating to the respiratory tract and may produce pulmonary edema" but gives no quantitative information. The *Documentation of TLV's* reports that in one investigation, irritation of the respiratory passages was observed in workers who had been exposed to concentrations up to 5000 ppm.
4. Evaluation of Warning Properties: Since no detailed information is available relating the irritant effects of methylene chloride to air concentrations and since adaptation to the odor occurs, methylene chloride is treated as a material with poor warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of methylene chloride. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• **Peak Above Ceiling Evaluation**

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of methylene chloride. Each measurement should consist of a 30-minute sample or a series of consecutive samples totalling 30 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure methylene chloride may be used. An analytical method for methylene chloride is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid methylene chloride.

• Non-impervious clothing which becomes wet with liquid methylene chloride should be removed promptly and not reworn until the methylene chloride is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where liquid methylene chloride may contact the eyes.

SANITATION

• Skin that becomes wet with liquid methylene chloride should be promptly washed or showered with soap or mild detergent and water to remove any methylene chloride.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to methylene chloride may occur and control methods which may be effective in each case:

Operation	Controls
Use as a solvent in paint and varnish removers; manufacture of aerosols; cold cleaning and ultrasonic cleaning; and as an extraction solvent for foods and furniture processing	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use as a cooling solvent in manufacture of cellulose acetate; in organic synthesis; and in plastics processing	Process enclosure; local exhaust ventilation
Use as a solvent in vapor degreasing of thermal switches and thermometers	Process enclosure; local exhaust ventilation
Use as a secondary refrigerant in air conditioning and scientific testing	General dilution ventilation; local exhaust ventilation; personal protective equipment

Operation	Controls
Use as an extraction solvent for edible fats, coca, butter, beer flavoring in hops, decaffeinated coffee, oleoresin manufacture, oils, waxes, perfumes, flavorings, and drugs	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use as a solvent for paints, lacquers, varnishes, enamels, adhesives, rubber cements, manufacture of printed circuit boards, as a carrier for pharmaceutical tablet coatings, shrink-fitting of synthetic rubber covers, and dyeing of synthetic fibers	General dilution ventilation; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If methylene chloride gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If methylene chloride gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water if the methylene chloride has not already evaporated. If methylene chloride soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of methylene chloride, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When methylene chloride has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND LEAK PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If methylene chloride is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. Collect for reclamation or absorb in vermiculite, dry sand, earth, or a similar material.

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RESPIRATORY PROTECTION FOR METHYLENE CHLORIDE

Condition	Minimum Respiratory Protection* Required Above 500 ppm
Vapor Concentration	
5000 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 5000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Option 1 - Full Display
RECORD# 99 - METHYL ETHYL KETONE

1 SUBSTANCE IDENTIFICATION

NAME OF SUBSTANCE - NAME	METHYL ETHYL KETONE
CAS REGISTRY NUMBER - RN	78-93-3
RELATED HSDB RECORDS - RELT(1)	ND
SYNONYMS - SY(1)	2-BUTANONE ** PEER REVIEWED **
SYNONYMS - SY(2)	3-BUTANONE ** PEER REVIEWED **
SYNONYMS - SY(3)	ACETONE, METHYL- ** UNREVIEWED **
SYNONYMS - SY(4)	AETHYLMETHYLKETON (GERMAN) ** UNREVIEWED **
SYNONYMS - SY(5)	BUTANONE ** PEER REVIEWED **
SYNONYMS - SY(6)	BUTANONE 2 (FRENCH) ** UNREVIEWED **
SYNONYMS - SY(7)	ETHYL METHYL CETONE (FRENCH) ** UNREVIEWED **
SYNONYMS - SY(8)	ETHYL METHYL KETONE ** PEER REVIEWED **
SYNONYMS - SY(9)	ETHYLMETHYLKETON (DUTCH) ** UNREVIEWED **
SYNONYMS - SY(10)	KETONE, ETHYL METHYL ** UNREVIEWED **
SYNONYMS - SY(11)	MEK ** PEER REVIEWED **
SYNONYMS - SY(12)	METHYL ACETONE ** UNREVIEWED **
SYNONYMS - SY(13)	METILETILCHETONE (ITALIAN) ** UNREVIEWED **
SYNONYMS - SY(14)	METYLOETYLOKETON (POLISH) ** UNREVIEWED **
SYNONYMS - SY(15)	AI3-07540 (USDA) ** UNREVIEWED **
SYNONYMS - SY(16)	Caswell No. 569 ** UNREVIEWED **
SYNONYMS - SY(17)	EPA Pesticide Chemical Code 044103 ** UNREVIEWED **
MOLECULAR FORMULA - MF	C4-H8-O ** UNREVIEWED **
WISWESSER LINE NOTATION - WLN	ND
RTECS NUMBER - RTEC	NIOSH/EL6475000
OHM-TADS NUMBER - OHMN	7216796

1 SUBSTANCE IDENTIFICATION (continued)

SHIPPING NAME/NUMBER - DOT/UN/NA/IMCO - SHPN(1)	UN 1193; Methyl ethyl ketone
SHIPPING NAME/NUMBER - DOT/UN/NA/IMCO - SHPN(2)	IMCO 3.2; Methyl ethyl ketone
SHIPPING NAME/NUMBER - DOT/UN/NA/IMCO - SHPN(3)	UN 1232; Methyl acetone
STCC NUMBER - STCC(1)	49 092 43; Methyl ethyl ketone
EPA HAZARDOUS WASTE NUMBER - HAZN(1)	U159; Methyl ethyl ketone
EPA HAZARDOUS WASTE NUMBER - HAZN(2)	F005; Methyl ethyl ketone
ASSOCIATED CHEMICALS - ASCH(1)	ND

3 CHEMICAL AND PHYSICAL PROPERTIES

COLOR/FORM - COFO(1)	COLORLESS LIQUID [SAX. DANGER PROPS INDUS MATER. 6TH ED 1984 p 549] ** UNREVIEWED **
ODOR - ODOR(1)	Moderately sharp, fragrant, mint-like odor. [CITATION General Electric Co; Material Safety Data Sheet #303 (1979)] ** UNREVIEWED **
ODOR - ODOR(2)	ACETONE-LIKE ODOR [MERCK INDEX. 10TH ED 1983 p 870] ** UNREVIEWED **
ODOR - ODOR(3)	Sweet, pleasant, pungent [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **
TASTE - TAST(1)	Detection limit 3.00 +or- 0.01 ppm [CITATION ASTM. Compilation of Odor and Taste Threshold Values Data p.24 (1978)] ** UNREVIEWED **
BOILING POINT - BP	79.6 DEG C [MERCK INDEX. 10TH ED 1983 p 870] ** UNREVIEWED **
MELTING POINT - MP(1)	-86.3 DEG C

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

MELTING POINT - MP(1)-cont.	[WEAST. HDBK CHEM & PHYS 67TH ED 1986-87 C-170] ** UNREVIEWED **

4 SAFETY AND HANDLING

HAZARDS SUMMARY - HAZS(1)	ND
FIRE POTENTIAL - FPOT(1)	FIRE HAZARD: DANGEROUS WHEN EXPOSED TO HEAT OR FLAME [SAX. DANGER PROPS INDUS MATER. 6TH ED 1984 p 549] ** UNREVIEWED **
FIRE POTENTIAL - FPOT(2)	BURNING RATE: 4.1 MM/MIN [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **
NFPA HAZARD CLASSIFICATION - NFPA(1)	Health: 1. 1= Materials only slightly hazardous to health. It may be desirable to wear self-contained breathing apparatus. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 325M-69] ** UNREVIEWED **
NFPA HAZARD CLASSIFICATION - NFPA(2)	Flammability: 3. 3= Materials which can be ignited under almost all normal temperature conditions. Water may be ineffective because of the low flash point. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 325M-69] ** UNREVIEWED **
NFPA HAZARD CLASSIFICATION - NFPA(3)	Reactivity: 0. 0= Materials which (in themselves) are normally stable even under fire exposure conditions and which are not reactive with water. Normal fire fighting procedures may be used. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 325M-69] ** UNREVIEWED **
FLAMMABLE LIMITS - FLMT(1)	% BY VOL. LOWER 1.4 @ 200 DEG F (93 DEG C), UPPER 11.4 @ 200 DEG F (93 DEG C) [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 325M-69] ** UNREVIEWED **
FLASH POINT - FLPT(1)	16 DEG F (-9 DEG C) Closed cup [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 325M-69] ** UNREVIEWED **
AUTOIGNITION TEMPERATURE - AUTO	960 DEG F (515 DEG C) [HAWLEY. CONDENSED CHEM DICTNRY 10TH ED 1981 p 678] ** UNREVIEWED **

4 SAFETY AND HANDLING (continued)

	********** Comment - JCK (Dynamac) 06/29/84 [NFPA. Fire Prot Guide Hazard Matls p.138 (1978)] Ignition temp: 759 deg F (404 deg C) **********
FIRE FIGHTING PROCEDURES - FIRP(1)	ALC FOAM, DRY CHEMICAL, OR CARBON DIOXIDE. [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(1)	Keep material away from explosives, oxidizing agents, poisons, organic peroxides and radioactive materials. [CITATION Int Tech Info Inst; Toxic & Haz Indust Chem Safety Manual p.336 (1982)] ** UNREVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(2)	Avoid copper [CITATION DLA/DOD; Hazardous Materials Info System #6810-00-N00-0021 (1982)] ** UNREVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(3)	CONTACT OF 1.5 G PORTIONS OF SOLID POTASSIUM TERT-BUTOXIDE WITH THE VAPORS OF 2-BUTANONE CAUSED IGNITION AFTER 1 & 0.5 MIN. [BRETHERICK. HDBK REAC CHEM HAZARD 2ND ED 1979 p 498] ** PEER REVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(4)	MIXING METHYL ETHYL KETONE & CHLOROSULFONIC ACID OR OLEUM IN A CLOSED CONTAINER CAUSED THE TEMP & PRESSURE TO INCR. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 491M-90] ** UNREVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(5)	DISTILLATION TO SMALL VOL OF A SMALL SAMPLE OF 4-YR-OLD MIXT OF 2-PROPANOL WITH 0.5% OF 2-BUTANONE LED TO A VIOLENT EXPLOSION, & PRESENCE OF PEROXIDES WAS SUBSEQUENTLY CONFIRMED. [BRETHERICK. HDBK REACTIVE CHEM HAZARDS 1985 p 446] ** UNREVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(6)	Avoid strong oxidizers, amines, ammonia, inorganic acids, caustics, isocyanates, alkanol, pyridines, and inorganic acids. [CITATION DLA/DOD; Hazardous Materials Info System #6810-00-K00-0330 (1982)] ** UNREVIEWED **

4 SAFETY AND HANDLING (continued)

ODOR THRESHOLD - ODRT(1)	Odor detection limit in air 2.00 ppm; odor recognition limit in air 5.50 ppm [CITATION ASTM. Compilation of Odor and Taste Threshold Values Data p.24 (1978)] ** UNREVIEWED **
ODOR THRESHOLD - ODRT(2)	0.7375 mg/cum [CITATION Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)] ** UNREVIEWED **
SKIN, EYE AND RESPIRATORY IRRITATIONS - SERI(1)	High atm concn ... are irritating to the eyes, nose, and throat ... prolonged skin contact may defat the skin and produce dermatitis. If splashed in the eyes it may produce painful irritation ... . [PATTY. INDUS HYG & TOX 3RD ED VOL2A,2B,2C 1981-82 p 4728] ** UNREVIEWED **
SKIN, EYE AND RESPIRATORY IRRITATIONS - SERI(2)	Vapor is irritating to human mucous membranes and conjuntivae @ 200 ppm after 15 min ... . [GOSSELIN. CTCP 5TH ED. 1984 II-185] ** UNREVIEWED **
PROTECTIVE EQUIPMENT & CLOTHING - EQUP(1)	ORG CANISTER OR AIR PACK; PLASTIC GLOVES [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **
PROTECTIVE EQUIPMENT & CLOTHING - EQUP(2)	Skin contact should be avoided by the use of protective gloves; goggles may also be necessary to prevent eye contact. /Ketones/ [ENCYC OCCUPAT HEALTH & SAFETY 1983 p 1173] ** UNREVIEWED **
PROTECTIVE EQUIPMENT & CLOTHING - EQUP(3)	The following types of respirators should be selected under the prescribed concentrations: 1000ppm: 1) Any powered air-purifying respirator with organic vapor cartridge(s). 2) Any chemical cartridge respirator with a full facepiece and organic vapor cartridges(s). 3000ppm: 1) Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister. 2) Any supplied-air respirator operated in a continuous flow mode. 3) Any self-contained breathing apparatus with a full facepiece. 4) Any supplied-air respirator with a full facepiece. Emergency or planned entry in unknown

4 SAFETY AND HANDLING (continued)

PROTECTIVE EQUIPMENT & CLOTHING - EQUP(3)-cont.

concentration or IDLH conditions: 1) Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode. Any supplied-air respirator with a full facepiece. 1) Any supplied-air respirator with a full face piece and operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode. Escape: 1) Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister. 2) Any appropriate escape-type self-contained breathing apparatus.
[NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985 p 60] ** UNREVIEWED **

OTHER PREVENTIVE MEASURES - OPRM(1)

Work practices and industrial hygiene techniques should minimize the volatilization of ketones in the workroom air in order to ensure that the exposure limits are not exceeded. /Ketones/
[ENCYC OCCUPAT HEALTH & SAFETY 1983 p 1173] ** UNREVIEWED **

OTHER PREVENTIVE MEASURES - OPRM(2)

If material on fire or involved in fire: Do not extinguish fire unless flow can be stopped. Use water in flooding quantities as fog. Solid streams of water may be ineffective. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Use "alcohol" foam, carbon dioxide, or dry chemical.
[AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 452] ** UNREVIEWED **

OTHER PREVENTIVE MEASURES - OPRM(3)

If material not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak if without hazard. Use water spray to disperse vapors and dilute standing pools of liquid.
[AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 452] ** UNREVIEWED **

4 SAFETY AND HANDLING (continued)

OTHER PREVENTIVE MEASURES - OPRM(4)	Personnel protection: Avoid breathing vapors. Keep upwind. Do not handle broken packages without protective equipment. Wash away any material which may have contacted the body with copious amounts of water or soap and water. [AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 452] ** UNREVIEWED **
OTHER PREVENTIVE MEASURES - OPRM(5)	A major concern in the painting studio is solvents, /including methyl ethyl ketone/. ... Precautions include ... use of dilution and local exhaust ventilation, control of storage areas, disposal of solvent soaked rags in covered containers, minimizing skin exposure and the use of respirators and other personal protective equipment. The control of fire hazards is also important, since many of the solvents are highly flammable. [CITATION Hart C; Journal of Environmental Health 49 (5): 282-86 (1987)] ** UNREVIEWED **
OTHER PREVENTIVE MEASURES - OPRM(6)	Contact lenses should not be worn when working with this chemical. [NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985 p 61] ** UNREVIEWED **
CLEANUP METHODS - CLUP(1)	Spills and leakage: Absorb on paper. Evaporate on glass or iron dish in hood. Burn the paper. [ITI. TOX & HAZARD INDUS CHEM SAFETY MANUAL 1982 p 337] ** UNREVIEWED **
DISPOSAL METHODS - DISP(1)	At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices. [CITATION SRP] ** UNREVIEWED **
DISPOSAL METHODS - DISP(2)	A good candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids. A good candidate for rotary

4 SAFETY AND HANDLING (continued)

DISPOSAL METHODS - DISP(2) -cont.	kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A good candidate for liquid injection incineration at a temperature range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds. [CITATION USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-14 (1981) EPA 68-03-3025] ** UNREVIEWED **
DISPOSAL METHODS - DISP(3)	Chemical Treatability of Methyl Ethyl Ketone; Concentration Process: Solvent Extraction; Chemical Classification: Aliphatics; Scale of Study: Laboratory Scale/Continuous Flow; Type of Wastewater Used: Industrial; Results of Study: 69% and 88% reduction; sequential extraction of waste water from lube-oil refining using butyl acetate (S/W= 0.10) and isobutylene (S/W= 0.101); RDC estractor used. [CITATION Earhart JP et al; Chemical Engineering Process 73 (5): 67-73 (1977) as cited in USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-110 (1982)] ** UNREVIEWED **
DISPOSAL METHODS - DISP(4)	Chemical Treatability of Methyl Ethyl Ketone; Concentration Process: Activated Carbon; Chemical Classification: Aliphatics; Scale of Study: Isotherm Test; Type of Wastewater Used: Pure Compound; Influent concentration: 1000 ppm; Results of Study: 46.8% reduction; 532 ppm final concn, 0.094 g/g carbon capacity. [CITATION Giusti DM et al; J Water Pollution Control Federation 49 (11): 2297-309 (1977) as cited in USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-134 (1982)] ** UNREVIEWED **

8 EXPOSURE STANDARDS AND REGULATIONS

IMMEDIATELY DANGEROUS TO LIFE OR HEALTH-IDLH(1)	3000 ppm [NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985 p 60] ** UNREVIEWED **

8 EXPOSURE STANDARDS AND REGULATIONS (continued)

ACCEPTABLE DAILY INTAKES - ADI(1)	One-day EPA SNARL is calculated at 7.5 mg/l; 10-day SNARL is calculated at 0.750 mg/l. [CITATION USEPA; SNARL Methyl Ethyl Ketone (Draft) (1981)] ** UNREVIEWED **
OSHA STANDARDS - OSHA(1)	Meets criteria for proposed OSHA medical records rule. [CITATION 47 FR 30420 (7/13/82)] ** UNREVIEWED **
OSHA STANDARDS - OSHA(2)	8-hr Time-Weighted avg: 200 ppm (590 mg/cu m) [CITATION 29 CFR 1910.1000 (7/1/86)] ** UNREVIEWED **
NIOSH RECOMMENDATIONS - NREC(1)	ND
THRESHOLD LIMIT VALUES - TLV(1)	Time Weighted Avg (TWA) 200 ppm, 590 mg/cu m; Short Term Exposure Limit (STEL) 300 ppm, 885 mg/cu m (1987-88) [ACGIH. TLVs 1987-88 p 26] ** UNREVIEWED **
THRESHOLD LIMIT VALUES - TLV(2)	A threshold limit value of 200 ppm, as a time-weighted average and a short term exposure limit of 300 ppm should prevent any injurious effects and minimize complaints about odor and irritation. [ACGIH. DOCUMENTATION OF TLVS 5TH ED 1986 p 395] ** UNREVIEWED **
OTHER OCCUPATIONAL PERMISSIBLE LEVELS - OOPL(1)	ND
CERCLA REPORTABLE QUANTITIES - CERC(1)	Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 5,000 lb or 2270 kg. The toll free telephone number of the NRC is (800) 424-8802; in the Washington metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.6 (section IV. D.3.b). [CITATION 50 FR 13456 (4/4/86)] ** UNREVIEWED **

8 EXPOSURE STANDARDS AND REGULATIONS (continued)

RCRA REQUIREMENTS - RCRA(1)	As stipulated in 40 CFR 261.33, when methyl ethyl ketone, as a commercial chemical product or manufacturing chemical intermediate or as an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed as a hazardous waste according to Federal and/or State regulations. Also defined as a hazardous waste is any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill into water or on dry land of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5). [CITATION 51 FR 28296 (8/6/86)] ** UNREVIEWED **
RCRA REQUIREMENTS - RCRA(2)	When Methyl ethyl ketone is a spent solvent, it is classified as a hazardous waste from a nonspecific source (F005), as stated in 40 CFR 261.31. [CITATION 40 CFR 261.31 (7/1/87)] ** UNREVIEWED **

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225 NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986
231 NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985
122 PATTY. INDUS HYG & TOX 3RD ED VOL2A,2B,2C 1981-82
212 SAX. DANGER PROPS INDUS MATER. 6TH ED 1984
222 WEAST. HDBK CHEM & PHYS 67TH ED 1986-87

Option 1 - Full Display
RECORD# 148 - METHYL ISOBUTYL KETONE

1 SUBSTANCE IDENTIFICATION

NAME OF SUBSTANCE - NAME	METHYL ISOBUTYL KETONE
CAS REGISTRY NUMBER - RN	108-10-1
RELATED HSDB RECORDS - RELT(1)	ND
SYNONYMS - SY(1)	2-METHYL-4-PENTANONE ** PEER REVIEWED **
SYNONYMS - SY(2)	2-METHYLPROPYL METHYL KETONE ** PEER REVIEWED **
SYNONYMS - SY(3)	2-PENTANONE, 4-METHYL- ** PEER REVIEWED **
SYNONYMS - SY(4)	4-METHYL-2-OXOPENTANE ** PEER REVIEWED **
SYNONYMS - SY(5)	4-METHYL-2-PENTANON (CZECH) ** UNREVIEWED **
SYNONYMS - SY(6)	4-METHYL-2-PENTANONE ** PEER REVIEWED **
SYNONYMS - SY(7)	4-METHYL-PENTAN-2-ON (DUTCH, GERMAN) ** UNREVIEWED **
SYNONYMS - SY(8)	4-METHYLPENTANONE-2 [BROWNING. TOX & METAB INDUS SOLV 1965 p 430] ** PEER REVIEWED **
SYNONYMS - SY(9)	4-METILPENTAN-2-ONE (ITALIAN) ** UNREVIEWED **
SYNONYMS - SY(10)	HEXON (CZECH) ** UNREVIEWED **
SYNONYMS - SY(11)	HEXONE ** PEER REVIEWED **
SYNONYMS - SY(12)	ISOBUTYL METHYL KETONE ** PEER REVIEWED **
SYNONYMS - SY(13)	ISOBUTYL-METHYLKETON (CZECH) ** UNREVIEWED **
SYNONYMS - SY(14)	ISOPROPYLACETONE ** PEER REVIEWED **
SYNONYMS - SY(15)	KETONE, ISOBUTYL METHYL ** PEER REVIEWED **
SYNONYMS - SY(16)	METHYL-ISOBUTYL-CETONE (FRENCH) ** UNREVIEWED **
SYNONYMS - SY(17)	METHYLISOBUTYLKETON (DUTCH, GERMAN) ** UNREVIEWED **
SYNONYMS - SY(18)	METILISOBUTILCHETONE (ITALIAN)

1 SUBSTANCE IDENTIFICATION (continued)

SYNONYMS - SY(19)	METYLOIZOBUTYLOKETON (POLISH) ** UNREVIEWED **
SYNONYMS - SY(20)	MIBK ** PEER REVIEWED **
SYNONYMS - SY(21)	MIK ** PEER REVIEWED **
SYNONYMS - SY(22)	SHELL MIBK ** UNREVIEWED **
SYNONYMS - SY(23)	AI3-01229 ** UNREVIEWED **
SYNONYMS - SY(24)	Caswell No. 574AA ** UNREVIEWED **
SYNONYMS - SY(25)	EPA Pesticide Chemical Code 044105 ** UNREVIEWED **
SYNONYMS - SY(26)	Isopropyl acetone ** UNREVIEWED **
MOLECULAR FORMULA - MF	C6-H12-O ** PEER REVIEWED **
WISWESSER LINE NOTATION - WLN	ND
RTECS NUMBER - RTEC	NIOSH/SA9275000
OHM-TADS NUMBER - OHMN	7216798
SHIPPING NAME/NUMBER - DOT/UN/NA/IMCO - SHPN(1)	UN 1245; Methyl isobutyl ketone
SHIPPING NAME/NUMBER - DOT/UN/NA/IMCO - SHPN(2)	IMCO 3.2; Methyl isobutyl ketone
STCC NUMBER - STCC(1)	49 092 45; Methyl isobutyl ketone (flammable liquid)
EPA HAZARDOUS WASTE NUMBER - HAZN(1)	U161; Methyl isobutyl ketone
EPA HAZARDOUS WASTE NUMBER - HAZN(2)	F003; Methyl isobutyl ketone
ASSOCIATED CHEMICALS - ASCH(1)	ND

3 CHEMICAL AND PHYSICAL PROPERTIES

COLOR/FORM - COFO(1)	COLORLESS LIQUID [MERCK INDEX. 10TH ED 1983 p 7491 ** PEER REVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

ODOR - ODOR(1)	PLEASANT ODOR [HAWLEY. CONDENSED CHEM DICTNRY 10TH ED 1981 p 682] ** PEER REVIEWED **
ODOR - ODOR(2)	HAS FAINT, KETONIC AND CAMPHOR ODOR [MERCK INDEX. 10TH ED 1983 p 749] ** PEER REVIEWED **
TASTE - TAST(1)	ND
BOILING POINT - BP	116.8 DEG C AT 760 MM HG [WEAST. HDBK CHEM & PHYS 67TH ED 1986-87 C-352] ** UNREVIEWED **
MELTING POINT - MP(1)	-84.7 DEG C [WEAST. HDBK CHEM & PHYS 67TH ED 1986-87 C-352] ** UNREVIEWED **

4 SAFETY AND HANDLING

HAZARDS SUMMARY - HAZS(1)	ND
FIRE POTENTIAL - FPOT(1)	KEEP AWAY FROM HEAT & OPEN FLAME. ... [SAX. DANGER PROPS INDUS MATER. 6TH ED 1984 p 1529] ** UNREVIEWED **
NFPA HAZARD CLASSIFICATION - NFPA(1)	Health: 2. 2= Materials hazardous to health, but areas may be entered freely with self-contained breathing apparatus. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-55] ** UNREVIEWED **
NFPA HAZARD CLASSIFICATION - NFPA(2)	Flammability: 3. 3= Liquids which can be ignited under almost all normal temp conditions. Water may be ineffective on these liq because of their low flash points. Solids which form coarse dusts, solids in shredded or fibrous form that create flash fires, solids that burn rapidly, usually because they contain their own oxygen, and any material that ignites spontaneously at normal temp in air. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-55] ** UNREVIEWED **
NFPA HAZARD CLASSIFICATION - NFPA(3)	Reactivity: 0. 0= Materials which are normally stable even under fire exposure

4 SAFETY AND HANDLING (continued)

NFPA HAZARD CLASSIFICATION - NFPA(3)-cont.	conditions and which are not reactive with water. Normal fire fighting procedures may be used. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-55] ** UNREVIEWED **
FLAMMABLE LIMITS - FLMT(1)	Lower: 1.4% @ 200 deg F; Upper: 7.5% @ 200 deg F [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-55] ** UNREVIEWED **
FLASH POINT - FLPT(1)	75 deg F open cup [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **
AUTOIGNITION TEMPERATURE - AUTO	860 deg F [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-55] ** UNREVIEWED **
FIRE FIGHTING PROCEDURES - FIRP(1)	ALCOHOL FOAM, CARBON DIOXIDE, DRY CHEMICAL. [SAX. DANGER PROPS INDUS MATER. 6TH ED 1984 p 1530] ** UNREVIEWED **
FIRE FIGHTING PROCEDURES - FIRP(2)	... WATER MAY BE INEFFECTIVE ... /BUT/ SHOULD BE USED TO KEEP FIRE-EXPOSED CONTAINERS COOL. IF LEAK OR SPILL HAS NOT IGNITED, USE WATER SPRAY TO DISPERSE VAPORS TO PROTECT MEN ATTEMPTING TO STOP LEAK. WATER SPRAY MAY BE USED TO FLUSH SPILLS AWAY FROM EXPOSURES & TO DILUTE SPILLS TO NON-FLAMMABLE MIXT. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-56] ** UNREVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(1)	Violent reaction with potassium tert-butoxide ... can react vigorously with reducing material. [SAX. DANGER PROPS INDUS MATER. 6TH ED 1984 p 1530] ** UNREVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(2)	Incompatibilities: strong oxidizers [NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985 p 134] ** UNREVIEWED **
ODOR THRESHOLD - ODRT(1)	0.10 ppm [PATTY. INDUS HYG & TOX 3RD ED VOL2A,2B,2C 1981-82 p 4747] ** PEER REVIEWED **
ODOR THRESHOLD - ODRT(2)	Air: 0.68 ul/l; water: 1.3 mg/l; odor safety class B; B= 50-90% of distracted persons perceive warning of TLV

4 SAFETY AND HANDLING (continued)

ODOR THRESHOLD - ODRT(2)-cont.	[CITATION Amoore JE, Hautala E; J Appl Toxicol 3 (6): 272-90 (1983)] ** UNREVIEWED **
ODOR THRESHOLD - ODRT(3)	0.47 ppm [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **
ODOR THRESHOLD - ODRT(4)	0.410 mg/cum [CITATION Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986) A-148] ** UNREVIEWED **
ODOR THRESHOLD - ODRT(5)	Odor detection limit in air 9.70x10-6 g/l (gas). [FAZZALARI. COMP ODOR & TASTE THRESHOLD VOL 1978 p 102] ** UNREVIEWED **
SKIN, EYE AND RESPIRATORY IRRITATIONS - SERI(1)	... /AT 100 PPM/ METHYL ISOBUTYL KETONE MAY IRRITATE EYES OF MORE SENSITIVE PERSON. [THIENES. CLIN TOX 5TH ED 1972 p 137] ** UNREVIEWED **
SKIN, EYE AND RESPIRATORY IRRITATIONS - SERI(2)	Vapor cause irritation of ... nose ... [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** UNREVIEWED **
PROTECTIVE EQUIPMENT & CLOTHING - EQUP(1)	Skin contacts should be avoided by the use of protective gloves; goggles may also be necessary to prevent eye contact. /Ketones/ [ENCYC OCCUPAT HEALTH & SAFETY 1983 p 1173] ** UNREVIEWED **
PROTECTIVE EQUIPMENT & CLOTHING - EQUP(2)	The following types of respirators should be selected under the prescribed concentrations: 500 ppm: 1) Any chemical cartridge respirator with organic vapor cartridge(s). 2) Any supplied-air respirator. 3) Any self-contained breathing apparatus. 1000 ppm: 1) Any powered air-purifying respirator with organic vapor cartridge(s). 2) Any chemical cartridge respirator with a full facepiece and organic vapor cartridges(s). 1250 ppm: 1) Any supplied-air respirator operated in a continuous flow mode. 2500 ppm: 1) Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister. 2) Any self-contained breathing apparatus with a full facepiece. 3) Any supplied-air respirator with a full

4 SAFETY AND HANDLING (continued)

PROTECTIVE EQUIPMENT & CLOTHING - EQUP(2)-cont.	facepiece. 4) Any supplied-air respirator with a tight-fitting facepiece operated in a continuous flow mode. 3000 ppm: 1) Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode. Emergency or planned entry in unknown concentration or IDLH conditions: 1) Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode. 2) Any supplied-air respirator with a full face piece and operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode. Escape: 1) Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister. 2) Any appropriate escape-type self-contained breathing apparatus. [NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985 p 134] ** UNREVIEWED **
OTHER PREVENTIVE MEASURES - OPRM(1)	Contact lenses should not be worn when working with this chemical. [NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985 p 135] ** UNREVIEWED **
OTHER PREVENTIVE MEASURES - OPRM(2)	Work practices and industrial hygiene techniques should minimize the volatilization of ketones in the workroom air in order to ensure that the exposure limits are not exceeded. /Ketones/ [ENCYC OCCUPAT HEALTH & SAFETY 1983 p 1173] ** UNREVIEWED **
OTHER PREVENTIVE MEASURES - OPRM(3)	If material on fire or involved in fire: Do not extinguish fire unless flow can be stopped. Use water in flooding quantities as fog. Solid streams of water may be ineffective. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Use "alcohol" foam, carbon dioxide, or dry chemical. [AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 454] ** UNREVIEWED **

4 SAFETY AND HANDLING (continued)

OTHER PREVENTIVE MEASURES - OPRM(4)	If material not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak if without hazard. Use water spray to disperse vapors and dilute standing pools of liquid. [AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 454] ** UNREVIEWED **
OTHER PREVENTIVE MEASURES - OPRM(5)	Personnel protection: Avoid breathing vapors. Keep upwind. Do not handle broken packages without protective equipment. Wash away any material which may have contacted the body with copious amounts of water or soap and water. [AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 454] ** UNREVIEWED **
CLEANUP METHODS - CLUP(1)	ND
DISPOSAL METHODS - DISP(1)	At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices. [CITATION SRP] ** UNREVIEWED **
DISPOSAL METHODS - DISP(2)	A good candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids. A good candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A good candidate for liquid injection incineration at a temperature range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds. [CITATION USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-14 (1981) EPA 68-03-3025] ** UNREVIEWED **

8 EXPOSURE STANDARDS AND REGULATIONS

IMMEDIATELY DANGEROUS TO LIFE OR HEALTH-IDLH(1)	3000 ppm [NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985 p 134] ** UNREVIEWED **
ACCEPTABLE DAILY INTAKES - ADI(1)	ND
OSHA STANDARDS - OSHA(1)	8-hr Time-Weighted avg: 100 ppm (410 mg/cu m) [CITATION 29 CFR 1910.1000 (7/1/86)] ** UNREVIEWED **
NIOSH RECOMMENDATIONS - NREC(1)	ND
THRESHOLD LIMIT VALUES - TLV(1)	Time Weighted Avg (TWA) 50 ppm, 205 mg/cu m; Short Term Exposure Limit (STEL) 75 ppm, 300 mg/cu m (1987-88) [ACGIH. TLVs 1987-88 p 27] ** UNREVIEWED **
THRESHOLD LIMIT VALUES - TLV(2)	A recommendation was made in 1979 to lower the time-weighted average threshold limit value from 100 ppm to 50 ppm and the short term exposure limit from 125 ppm to 75 ppm to protect workers from the irritant effects of methyl isobutyl ketone and its potential effect on the kidneys. These values were adopted in 1981. [MORGAN. RECOG MANAG PEST POISONINGS. 1982 p 402] ** UNREVIEWED **
CERCLA REPORTABLE QUANTITIES - CERC(1)	Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 5,000 lb or 2270 kg. The toll free telephone number of the NRC is (800) 424-8802; in the Washington metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.6 (section IV. D.3.b). [CITATION 50 FR 13456 (4/4/86)] ** UNREVIEWED **
RCRA REQUIREMENTS - RCRA(1)	As stipulated in 40 CFR 261.33, when Methyl isobutyl ketone, as a commercial chemical product or manufacturing chemical intermediate or as an off-specification

8 EXPOSURE STANDARDS AND REGULATIONS (continued)

RCRA REQUIREMENTS - RCRA(1) -cont.	commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed as a hazardous waste according to Federal and/or State regulations. Also defined as a hazardous waste is any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill into water or on dry land of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5). [CITATION 51 FR 28296 (8/6/86)] ** UNREVIEWED **
RCRA REQUIREMENTS - RCRA(2)	When Methyl isobutyl ketone is a spent solvent, it is classified as a hazardous waste from a nonspecific source (F003), as stated in 40 CFR 261.31. [CITATION 40 CFR 261.31 (7/1/87)] ** UNREVIEWED **

Option 1 - Full Display

RECORD# 146 - METHYL ISOBUTYL KETONE (continued)

SOURCE BIBLIOGRAPHY

262 AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987
268 ACGIH. TLVs 1987-88
10 BROWNING. TOX & METAB INDUS SOLV 1965
224 CHRIS. HAZARD CHEM DATA VOL. II 1984-5
CIT CITATION
158 ENCYC OCCUPAT HEALTH & SAFETY 1983
179 FAZZALARI. COMP ODOR & TASTE THRESHOLD VOL 1978
159 HAWLEY. CONDENSED CHEM DICTNRY 10TH ED 1981
157 MERCK INDEX. 10TH ED 1983
143 MORGAN. RECOG MANAG PEST POISONINGS. 1982
225 NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986
231 NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985
122 PATTY. INDUS HYG & TOX 3RD ED VOL2A,2B,2C 1981-82
212 SAX. DANGER PROPS INDUS MATER. 6TH ED 1984
11 THIENES. CLIN TOX 5TH ED 1972
222 WEAST. HDBK CHEM & PHYS 67TH ED 1986-87

ORIGINAL (Red)

1 SUBSTANCE IDENTIFICATION

NAME OF SUBSTANCE - NAME: 4-METHYL-2-PENTANOL

CAS REGISTRY NUMBER - RN: 108-11-2

RELATED HSDB RECORDS - RELT(1): ND

SYNONYMS - SY(1): 1,3-DIMETHYLBUTANOL
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS. 1978 325M:140] ** PEER REVIEWED **

SYNONYMS - SY(2): 2-METHYL-4-PENTANOL ** PEER REVIEWED **

SYNONYMS - SY(3): 2-PENTANOL, 4-METHYL- ** PEER REVIEWED **

SYNONYMS - SY(4): 3-MIC ** PEER REVIEWED **

SYNONYMS - SY(5): 4-METHYLPENTANOL-2
[HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **

SYNONYMS - SY(6): ALCOHOL METHYL AMYLIQUE (FRENCH)
[NIOSH. REG TOX EFFECT CHEM SUB 1979 V2 2053] ** PEER REVIEWED **

SYNONYMS - SY(7): ISOBUTYLMETHYLCARBINOL ** PEER REVIEWED **

SYNONYMS - SY(8): ISOBUTYLMETHYLMETHANOL ** PEER REVIEWED **

SYNONYMS - SY(9): MAOH ** PEER REVIEWED **

SYNONYMS - SY(10): METHYLAMYL ALCOHOL
[HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **

SYNONYMS - SY(11): METHYLISOBUTYL CARBINOL ** PEER REVIEWED **

SYNONYMS - SY(12): METILAMIL ALCOHOL (ITALIAN)
[NIOSH. REG TOX EFFECT CHEM SUB 1979 V2 2053] ** PEER REVIEWED **

SYNONYMS - SY(13): MIBC ** PEER REVIEWED **

SYNONYMS - SY(14): MIC ** PEER REVIEWED **

MOLECULAR FORMULA - MF: C6-H14-O ** PEER REVIEWED **

WISWESSER LINE NOTATION - WLN: QY&1Y
[NIOSH. REG TOX EFFECT CHEM SUB 1976 p 8203] ** PEER REVIEWED **

RTECS NUMBER - RTEC: NIOSH/SA7350000

ORIGINAL (Red)

1 SUBSTANCE IDENTIFICATION (continued)

OHM-TADS NUMBER - OHMN	7216791
SHIPPING NAME/NUMBER - DOT/UN/NA/IMCO - SHPN(1)	ND
STCC NUMBER - STCC(1)	ND
EPA HAZARDOUS WASTE NUMBER - HAZN(1)	ND
ASSOCIATED CHEMICALS - ASCH(1)	ND

2 MANUFACTURING/USE INFORMATION

METHODS OF MANUFACTURING - MMFG(1)	HYDROGENATION OF MESITYL OXIDE OR HYDROGENATION OF METHYL ISOBUTYL KETONE [SRI] ** PEER REVIEWED **
METHODS OF MANUFACTURING - MMFG(2)	...PREPARED COMMERCIALLY BY REDN MESITYL OXIDE IN ACETIC ACID SOLN WITH PLATINUM, OR OVER REDUCED COPPER ON ASBESTOS @ 180 DEG C. [PATTY. INDUS HYG & TOX 2ND ED VOL2 1963 p 1459] ** PEER REVIEWED **
IMPURITIES - IMP(1)	ND
FORMULATIONS/PREPARATIONS - FORM(1)	GRADE: TECHNICAL [HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **
MANUFACTURERS - MFS(1)	SHELL CHEM CO, BASE CHEMS, DEER PARK, TEX, DOMINGUEZ, CALIF [SRI] ** PEER REVIEWED **
MANUFACTURERS - MFS(2)	UNION CARBIDE CORP, CHEMS & PLASTICS DIV, INSTITUTE & SOUTH CHARLESTON, W VA [SRI] ** PEER REVIEWED **
OTHER MANUFACTURING INFORMATION - OMIN(1)	ND
MAJOR USES - USE(1)	FROTHER IN FROTH FLOTATION OF MINERALS SUCH AS SILICA, METAL ORES; IN BENEFICIATION OF COAL; LATENT SOLVENT IN BRUSHING & HOT SPRAY LACQUERS; IN NITROCELLULOSE LACQUERS [SRI] ** PEER REVIEWED **
MAJOR USES - USE(2)	SOLVENT FOR DYESTUFFS, OILS, GUMS, RESINS,

ORIGINAL (Red)

2 MANUFACTURING/USE INFORMATION (continued)

MAJOR USES - USE(2)-cont.	WAXES, NITROCELLULOSE & ETHYLCELLULOSE; ORG SYNTHESIS; FROTH FLOTATION [HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **
MAJOR USES - USE(3)	IN MFR LUBRICANT ADDITIVES, SOLVENTS, PLASTICIZERS, LACQUERS; IN BRAKE FLUIDS AS FROTHING AGENT [BROWNING. TOX & METAB INDUS SOLV 1965 p 368] ** PEER REVIEWED **
CONSUMPTION PATTERNS - CPAT(1)	ND [SRI] ** PEER REVIEWED **
U.S. PRODUCTION - PROD(1)	(1972) 1.81X10+10 GRAMS [SRI] ** PEER REVIEWED **
U.S. PRODUCTION - PROD(2)	(1973) 1.59X10+10 GRAMS (EST) [SRI] ** PEER REVIEWED **
U.S. IMPORTS - IMPT(1)	(1972) ND [SRI] ** PEER REVIEWED **
U.S. IMPORTS - IMPT(2)	(1975) ND [SRI] ** PEER REVIEWED **
U.S. EXPORTS - EXPT(1)	(1972) ND [SRI] ** PEER REVIEWED **
U.S. EXPORTS - EXPT(2)	(1975) ND [SRI] ** PEER REVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES

COLOR/FORM - COFO(1)	COLORLESS LIQ [HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **
ODOR - ODOR(1)	ND
TASTE - TAST(1)	ND
BOILING POINT - BP	133 DEG C @ 760 MM HG [WEAST. HDBK CHEM & PHYS 60TH ED 1979 C-420] ** PEER REVIEWED **
MELTING POINT - MP	-90 DEG C [PATTY. INDUS HYG & TOX 2ND ED VOL2 1963 p 1459] ** PEER REVIEWED **
MOLECULAR WEIGHT - MW	102.18 ** PEER REVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

CORROSIVITY - CORR(1)	ND
CRITICAL TEMPERATURE & PRESSURE - CTP(1)	ND
DENSITY/SPECIFIC GRAVITY - DEN	0.8075 @ 20 DEG C/4 DEG C [WEAST. HDBK CHEM & PHYS 60TH ED 1979 C-420] ** PEER REVIEWED **
DISSOCIATION CONSTANTS - DSC(1)	ND
HEAT OF COMBUSTION - HTC	ND
HEAT OF VAPORIZATION - HTV	ND
OCTANOL/WATER PARTITION COEFFICIENT - OWPC	ND
PH - PH	ND
SOLUBILITIES - SOL(1)	SLIGHTLY SOL IN WATER; SOL IN ALC & ETHER [WEAST. HDBK CHEM & PHYS 60TH ED 1979 C-420] ** PEER REVIEWED **
SOLUBILITIES - SOL(2)	MISCIBLE WITH MOST COMMON ORG SOLVENTS [HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **
SPECTRAL PROPERTIES - SPEC(1)	INDEX OF REFRACTION: 1.4100 @ 20 DEG C/D [WEAST. HDBK CHEM & PHYS 60TH ED 1979 C-420] ** PEER REVIEWED **
SURFACE TENSION - SURF	ND
VAPOR DENSITY - VAPD	ND
VAPOR PRESSURE - VAP	2.8 MM HG @ 20 DEG C [HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **
RELATIVE EVAPORATION RATE - EVAP(1)	ND
VISCOSITY - VISC	ND
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(1)	WT/GAL 5.72 LB @ 20 DEG C; SETS TO A GLASS BELOW -90 DEG C [HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(2)

CONVERSION FACTORS: 1 PPM= 4.17 MG/CU M; 1 MG/L= 239.3 PPM
[BROWNING. TOX & METAB INDUS SOLV 1965 p 368] ** PEER REVIEWED **

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(3)

% IN SATURATED AIR: 0.46 @ 20 DEG C; DENSITY OF SATURATED AIR: 1.01 (AIR= 1)
[PATTY. INDUS HYG & TOX 2ND ED VOL2 1963 p 1459] ** PEER REVIEWED **

4 SAFETY AND HANDLING

HAZARDS SUMMARY - HAZS(1)

ND

DOT EMERGENCY GUIDELINES - DOT(1)

Fire or Explosion: Flammable/combustible material; may be ignited by heat, sparks or flames. Vapors may travel to a source of ignition and flash back. Container may explode in heat of fire. Vapor explosion hazard indoors, outdoors or in sewers. Runoff to sewer may create fire or explosion hazard.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-26] ** GC REVIEWED **

DOT EMERGENCY GUIDELINES - DOT(2)

Health Hazards: May be poisonous if inhaled or absorbed through skin. Vapors may cause dizziness or suffocation. Contact may irritate or burn skin and eyes. Fire may produce irritating or poisonous gases. Runoff from fire control or dilution water may cause pollution.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-26] ** GC REVIEWED **

DOT EMERGENCY GUIDELINES - DOT(3)

Emergency Action: Keep unnecessary people away; isolate hazard area and deny entry. Stay upwind; keep out of low areas. Self-contained breathing apparatus (SCBA) and structural firefighter's protective clothing will provide limited protection. Isolate for 1/2 mile in all directions if tank car or truck is involved in fire. CALL CHEMTREC AT 1-800-424-9300 FOR EMERGENCY ASSISTANCE. If water pollution occurs, notify the appropriate authorities.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-26] ** GC REVIEWED **

DOT EMERGENCY GUIDELINES -

Fire: Small Fires: Dry chemical, CO2,

4 SAFETY AND HANDLING (continued)

DOT EMERGENCY GUIDELINES - DOT(4)-cont.

Halon, water spray or alcohol foam. Large Fires: Water spray, fog or alcohol foam is recommended. Move container from fire area if you can do it without risk. Cool containers that are exposed to flames with water from the side until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-26] ** QC REVIEWED **

DOT EMERGENCY GUIDELINES - DOT(5)

Spill or Leak: Shut off ignition sources; no flares, smoking or flames in hazard area. Stop leak if you can do it without risk. Water spray may reduce vapor; but it may not prevent ignition in closed spaces. Small Spills: Take up with sand or other noncombustible absorbent material and place into containers for later disposal. Large Spills: Dike far ahead of liquid spill for later disposal.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-26] ** QC REVIEWED **

DOT EMERGENCY GUIDELINES - DOT(6)

First Aid: Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen. In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water. Remove and isolate contaminated clothing and shoes at the site.
[DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-26] ** QC REVIEWED **

* FLAMMABLE PROPERTIES - FLAM

FIRE POTENTIAL - FPOT(1)

MODERATE FIRE RISK.
[HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **

NFPA HAZARD CLASSIFICATION - NFPA(1)

HEALTH: 2. 2= MATERIALS HAZARDOUS TO HEALTH, BUT AREAS...ENTERED FREELY WITH FULL-FACED MASK SELF-CONTAINED BREATHING APPARATUS /WITH/...EYE PROTECTION.
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS. 1978 325M-140] ** PEER REVIEWED **

ORIGINAL (Red)

4 SAFETY AND HANDLING (continued)

* FLAMMABLE PROPERTIES - FLAM

NFPA HAZARD CLASSIFICATION - NFPA(2)	FLAMMABILITY: 2. 2=MATERIALS WHICH MUST BE MODERATELY HEATED BEFORE IGNITION WILL OCCUR. WATER SPRAY MAY BE USED. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS. 1978 325M-140] ** PEER REVIEWED **
FLAMMABLE LIMITS - FLMT(1)	ND
FLASH POINT - FLPT(1)	105 DEG F OC [HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **
AUTOIGNITION TEMPERATURE - AUTO	ND

* FIRE FIGHTING INFORMATION - FIRE

FIRE FIGHTING PROCEDURES - FIRP(1)	ALCOHOL FOAM. [SAX. DANGER PROPS INDUS MATER 5TH ED 1979 p 807] ** PEER REVIEWED **
INTENSITY OF HEAT - INTH(1)	ND
TOXIC COMBUSTION PRODUCTS - TOXC(1)	ND
OTHER FIRE FIGHTING HAZARDS - OFHZ(1)	ND
EXPLOSIVE LIMITS AND POTENTIAL - EXPL(1)	IN AIR, 1-5.5%. [HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **

* HAZARDOUS REACTIONS - HAZR

REACTIVITIES & INCOMPATIBILITIES - REAC(1)	ND
DECOMPOSITION - DCMP(1)	ND
POLYMERIZATION - POLY(1)	ND
OTHER HAZARDOUS REACTIONS - OHAZ(1)	ND

* WARNING PROPERTIES - WRNP

ODOR THRESHOLD - ODRT(1)	ND

ORIGINAL (Red)

4 SAFETY AND HANDLING (continued)

* WARNING PROPERTIES - WRNP

SKIN, EYE AND RESPIRATORY IRRITATIONS - SERI(1)	ND
PREVENTIVE MEASURES - PRVN	
PROTECTIVE EQUIPMENT & CLOTHING - EQUP(1)	ND
OTHER PREVENTIVE MEASURES - OPRM(1)	ND
STABILITY/SHELF LIFE - SSL(1)	STABLE LIQ [HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **
SHIPMENT METHODS AND REGULATIONS - SHIP(1)	CONTAINERS: DRUMS; TANK CARS. [HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977 p 559] ** PEER REVIEWED **
STORAGE CONDITIONS - STRG(1)	ND
CLEANUP METHODS - CLUP(1)	ND
DISPOSAL METHODS - DISP(1)	ND
RADIATION LIMITS AND POTENTIAL - RADL(1)	ND

EXPOSURE STANDARDS AND REGULATIONS

IMMEDIATELY DANGEROUS TO LIFE OR HEALTH-IDLH(1)	ND
ACCEPTABLE DAILY INTAKES - ADI(1)	ND
ALLOWABLE TOLERANCES - ATOL(1)	ND

* OCCUPATIONAL PERMISSIBLE LEVELS - OPL

OSHA STANDARDS - OSHA(1)	ND
NIOSH RECOMMENDATIONS - NREC(1)	ND
THRESHOLD LIMIT VALUES - TLV(1)	Time Weighted Avg (TWA) 25 ppm, 104 mg/cu m, skin; Short Term Exposure Limit (STEL) 40 ppm, 166 mg/cu m, skin (1976)

8 EXPOSURE STANDARDS AND REGULATIONS (continued)

* OCCUPATIONAL PERMISSIBLE LEVELS - OPL
THRESHOLD LIMIT VALUES - [ACGIH. TLVs 1989-90. p 30]
TLV(1)-cont. ** QC REVIEWED **

OTHER OCCUPATIONAL PERMISSIBLE LEVELS - OOPL(1) ND

* OTHER STANDARDS AND REGULATIONS - OREG

WATER STANDARDS - WSTD(1) ND

ATMOSPHERIC STANDARDS - ASTD(1) ND

SOIL STANDARDS - SSTD(1) ND

CERCLA REPORTABLE QUANTITIES - CERC(1) ND

TSCA REQUIREMENTS - TSCA(1) ND

RCRA REQUIREMENTS - RCRA(1) ND

FIFRA REQUIREMENTS - FIFR(1) ND

FDA REQUIREMENTS - FDA(1) ND

9 MONITORING AND ANALYSIS METHODS

SAMPLING PROCEDURES - SAMP(1) ND

ANALYTIC LABORATORY METHODS - ALAB(1) ND

CLINICAL LABORATORY METHODS - CLAB(1) ND

NO COMMENTS ARE CURRENTLY ASSOCIATED WITH THIS RECORD

SOURCE BIBLIOGRAPHY

307 ACGIH. TLVs 1989-90.
10 BROWNING. TOX & METAB INDUS SOLV 1965
274 DOT. EMERGENCY RESPONSE GUIDEBOOK 1987
93 HAWLEY. CONDENSED CHEM DICTNRY 9TH ED 1977
98 NFPA. FIRE PROTECT GUIDE HAZARD MATLS. 1978
65 NIOSH. REG TOX EFFECT CHEM SUB 1976
118 NIOSH. REG TOX EFFECT CHEM SUB 1979
40 PATTY. INDUS HYG & TOX 2ND ED VOL2 1963
94 SAX. DANGER PROPS INDUS MATER 5TH ED 1979
SRI SRI
97 WEAST. HDBK CHEM & PHYS 60TH ED 1979

Occupational Health Guideline for Tetrachloroethylene*

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $CCl_2 = CCl_2$
- Synonyms: Perchloroethylene; perchlorethylene; tetrachlorethylene; perk
- Appearance and odor: Colorless liquid with an odor like chloroform or ether.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for tetrachloroethylene is 100 parts of tetrachloroethylene per million parts of air (ppm) averaged over an eight-hour work shift, with a ceiling level of 200 ppm and a maximum acceptable peak of 300 ppm for 5 minutes in any three-hour period. NIOSH has recommended that the permissible exposure limit be reduced to 50 ppm (339 mg/m³) averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling level of 100 ppm (678 mg/m³) averaged over a 15-minute period. The NIOSH Criteria Document for Tetrachloroethylene should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Tetrachloroethylene can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

- **Effects of overexposure**

1. Short-term Exposure: Tetrachloroethylene may cause headache, nausea, drowsiness, dizziness, incoordination, and unconsciousness. It may also cause irritation of the eyes, nose, and throat and flushing of the face and neck. In addition, it might cause liver damage with such findings as yellow jaundice and dark urine. The liver damage may become evident several weeks after the exposure.

2. Long-term Exposure: Prolonged or repeated overexposure to liquid tetrachloroethylene may cause irritation of the skin. It might also cause damage to the liver and kidneys.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to tetrachloroethylene.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to tetrachloroethylene at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the liver and the cardiovascular and neurological systems should be stressed. The skin should be examined for evidence of chronic disorders.

—Liver function tests: Tetrachloroethylene may cause liver damage. A profile of liver function should be obtained by using a medically acceptable array of biochemical tests.

—Urinalysis: Since kidney damage has also been observed from exposure, a urinalysis should be obtained to include at minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

Tetrachloroethylene vapor is a narcotic. Rats did not survive when exposed for longer than 12-18 minutes to 12,000 ppm; when exposed repeatedly to 470 ppm they showed liver and kidney injury. Cardiac arrhythmias

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These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

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attributed to sensitization of the myocardium to epinephrine have been observed with certain other chlorinated hydrocarbons, but exposure of dogs to concentrations of 5000 and 10,000 ppm tetrachloroethylene did not produce this phenomenon. Four human subjects were unable to tolerate 5000 ppm in a chamber for 6 minutes. They experienced vertigo, nausea, and mental confusion during the 10 minutes following cessation of exposure. In an industrial exposure to an average concentration of 275 ppm for 3 hours, followed by 1100 ppm for 30 minutes, a worker lost consciousness; there was apparent clinical recovery 1 hour after exposure but the monitored concentration of tetrachloroethylene in the patient's expired air diminished slowly over a 2-week period. Long-term industrial exposures have been reported to cause various neuropathies, such as numbness, trembling, neuritis, and defects of memory. During the second and third post-exposure weeks, the results of liver function tests became abnormal, suggesting that acute exposure had had a significant effect upon the liver. Other instances of liver injury following industrial exposure have been reported. Other effects on humans of inhalation of various concentrations are as follows: 2000 ppm, mild narcosis within 5 minutes; 600 ppm, sensation of numbness around the mouth, dizziness, and some incoordination after 10 minutes. In human experiments, 7-hour exposures at 100 ppm resulted in mild irritation of the eyes, nose, and throat; flushing of the face and neck; headache; somnolence; and slurred speech. Exposure of the skin to the liquid for 40 minutes resulted in a progressively severe burning sensation beginning within 5 to 10 minutes; the result was marked erythema, which subsided after 1 to 2 hours. The liquid sprayed into rabbits' eyes produced immediate pain and blepharospasm; patches of epithelium were lost, but the eyes recovered completely within 2 days.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 165.85
  2. Boiling point (760 mm Hg): 121.2 C (250 F)
  3. Specific gravity (water = 1): 1.62
  4. Vapor density (air = 1 at boiling point of tetrachloroethylene): 5.83
  5. Melting point: −22.4 C (−8 F)
  6. Vapor pressure at 20 C (68 F): 14 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): 0.015
  8. Evaporation rate (butyl acetate = 1): 2.8
- **Reactivity**
  1. Conditions contributing to instability: Heat.
  2. Incompatibilities: Tetrachloroethylene reacts with strong oxidizers and chemically active metals such as barium, lithium, and beryllium.
  3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, phosgene, and carbon monoxide) may be released when tetrachloroethylene decomposes.
  4. Special precautions: Liquid tetrachloroethylene will attack some forms of plastics, rubber, and coatings.
- **Flammability**
  1. Not combustible
- **Warning properties**
  1. Odor Threshold: Both May and Stern state that 50 ppm is the odor threshold for tetrachloroethylene.
  2. Eye Irritation Level: Grant reports that "exposure to high concentrations of (tetrachloroethylene) vapor causes mild sensation of irritation to the eyes, but serious injury is not likely." The exact concentrations producing irritation are not mentioned by Grant.

Spector, however, reports that after a 20- to 30-minute exposure to 206 to 235 ppm, eye irritation occurs in humans.

Patty reports "very slight irritation of the eyes" among humans at 106 ppm.

3. Other Information: Spector reports that a 10-minute exposure to 513 to 690 ppm produces nose and throat irritation.

4. Evaluation of Warning Properties: Since the odor threshold of tetrachloroethylene is below the permissible exposure limit, and since eye irritation occurs at a concentration only twice the permissible exposure limit, its warning properties are considered to be adequate.

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of tetrachloroethylene. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Peak Above Ceiling Evaluation**

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of tetrachloroethylene. Each measurement should consist of a 30-minute sample or a series of consecutive samples totalling 30 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of

three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure tetrachloroethylene may be used. An analytical method for tetrachloroethylene is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid tetrachloroethylene.

• Non-impervious clothing which becomes contaminated with liquid tetrachloroethylene should be removed promptly and not reworn until the tetrachloroethylene is removed from the clothing.

• Clothing wet with liquid tetrachloroethylene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of tetrachloroethylene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the tetrachloroethylene, the person performing the operation should be informed of tetrachloroethylene's hazardous properties.

• Employees should be provided with and required to use splash-proof safety goggles where liquid tetrachloroethylene may contact the eyes.

SANITATION

• Skin that becomes contaminated with liquid tetrachloroethylene should be promptly washed or showered with soap or mild detergent and water to remove any tetrachloroethylene.

• Employees who handle liquid tetrachloroethylene should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to tetrachloroethylene may occur and control methods which may be effective in each case:

Operation	Controls
Use as dry cleaning solvent; as degreasing and metal cleaning agent; in vapor degreasing of metal parts	Local exhaust ventilation; general dilution; personal protective equipment
Use as chemical intermediate in production of fluorocarbons, pesticides, and trichloroacetic acid	Process enclosure; local exhaust ventilation; general dilution ventilation
Use as scouring, sizing, desizing, solvent and greaser remover in processing and finishing of textiles	Local exhaust ventilation; general dilution; personal protective equipment
Use as general industrial solvent in rubber, textile, printing, soap, and paint remover industries	Local exhaust ventilation; general dilution; personal protective equipment
Use as extraction agent for vegetable and mineral oils and in pharmaceutical industry; as vermifuge; as laundry treatment for presoaking and as drying medium in metal and wood industries	Local exhaust ventilation; general dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If tetrachloroethylene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If tetrachloroethylene gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If tetrachloroethylene soaks through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of tetrachloroethylene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When tetrachloroethylene has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If tetrachloroethylene is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. Collect for reclamation or absorb in vermiculite, dry sand, earth, or a similar material.

• Waste disposal method:

Tetrachloroethylene may be disposed of by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.

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* SPECIAL NOTE

Tetrachloroethylene appears on the OSHA "Candidate List" of chemicals being considered for further scientific review regarding its carcinogenicity (*Federal Register*, Vol. 45, No. 157, pp. 5372-5379, 12 August 1980). The International Agency for Research on Cancer (IARC) has evaluated the data on this chemical and has concluded that it causes cancer. See *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man*, Volume 20, 1979.

RESPIRATORY PROTECTION FOR TETRACHLOROETHYLENE

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
500 ppm or less	Any chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s). A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 500 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Tetrahydrofuran

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: C_4H_8O
- Synonyms: Diethylene oxide; tetramethylene oxide; THF
- Appearance and odor: Colorless liquid with an ether-like odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for tetrahydrofuran is 200 parts of tetrahydrofuran per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 590 milligrams of tetrahydrofuran per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Tetrahydrofuran can affect the body if it is inhaled, is swallowed, or comes in contact with the eyes or skin.

- **Effects of overexposure**

1. Short-term Exposure: Overexposure to tetrahydrofuran may cause irritation of the eyes and nose, nausea, dizziness, and headache.

2. Long-term Exposure: Prolonged or repeated exposure to tetrahydrofuran may cause drying of the skin.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to tetrahydrofuran.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to tetrahydrofuran at potentially hazardous levels:

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from tetrahydrofuran exposure.

—Skin disease: Tetrahydrofuran can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver disease: Although tetrahydrofuran is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Kidney disease: Although tetrahydrofuran is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of tetrahydrofuran might cause exacerbation of symptoms due to its irritant properties.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

- **Summary of toxicology**

Tetrahydrofuran is an anesthetic agent and a mild upper respiratory tract irritant. Exposure of animals to vapor above 3000 ppm for 8 hours daily for 20 days produced irritation of the upper respiratory tract. Some injury to the liver and kidneys was observed, which was possibly due to impurities, since other studies have not confirmed this finding. Concentrations above 25,000 ppm produced anesthesia, with a small margin of safety between anesthesia and death. Severe headaches were

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noted among technicians performing this experiment. Daily 6-hour exposures of dogs for 3 to 4 weeks at 200 ppm produced only a slight change in pulse pressure, but no other signs were noted, even when continued for a total of 9 weeks followed by an additional 3 weeks' exposure at nearly 400 ppm. This substance was irritating to the skin of rabbits when applied in aqueous solutions exceeding 20% concentration, although it has not been observed to be a significant skin irritant or sensitizer in industrial practice. No chronic systemic effects have been reported in humans, although nausea, dizziness, and headaches are said to occur with overexposure and are readily reversible in fresh air.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 72
2. Boiling point (760 mm Hg): 66 C (151 F)
3. Specific gravity (water = 1): 0.9
4. Vapor density (air = 1 at boiling point of tetrahydrofuran): 2.5
5. Melting point: −108 C (−163 F)
6. Vapor pressure at 20 C (68 F): 145 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Miscible in all proportions
8. Evaporation rate (butyl acetate = 1): 14.5

- **Reactivity**

1. Conditions contributing to instability: Heat and sunlight
2. Incompatibilities: Contact with strong oxidizing agents may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving tetrahydrofuran.
4. Special precautions: Tetrahydrofuran will attack some forms of plastics, rubber, and coatings. Storage in the presence of air and light causes the formation of explosive peroxides that remain dissolved in tetrahydrofuran. Containers may explode when their caps or stoppers are removed.

- **Flammability**

1. Flash point: −14.5 C (6 F) (closed cup)
2. Autoignition temperature: 321 C (610 F)
3. Flammable limits in air, % by volume: Lower: 2; Upper: 11.8
4. Extinguishant: Dry chemical, alcohol foam, carbon dioxide

- **Warning properties**

1. Odor Threshold: May and Summer both report an odor threshold for tetrahydrofuran of 30 ppm.
2. Eye Irritation Level: Sax reports that tetrahydrofuran is an eye irritant, and Stecher, Browning, and the ILO indicate that it is a mucous membrane irritant, but the concentrations which produce irritation are not given. The *Handbook of Organic Industrial Solvents* reports that tetrahydrofuran "may cause irritation to mucuous membranes at concentrations higher than the threshold limit," but no quantitative information is available concerning the threshold of eye irritation.
3. Other Information: "The TLV of 200 ppm is recommended to protect against irritative effects and has a wide margin of safety for narcotic and systemic effects," according to the *Documentation of TLV's.*
4. Evaluation of Warning Properties: Since the odor threshold of tetrahydrofuran is well below the permissible exposure limit, it is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Method**

Sampling and analyses may be performed by collection of tetrahydrofuran vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure tetrahydrofuran may be used. An analytical method for tetrahydrofuran is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid tetrahydrofuran.

• Clothing wet with liquid tetrahydrofuran should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of tetrahydrofuran from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the tetrahydrofuran, the person performing the operation should be informed of tetrahydrofuran's hazardous properties.

• Any clothing which becomes wet with liquid tetrahydrofuran should be removed immediately and not reworn until the tetrahydrofuran is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where liquid tetrahydrofuran may contact the eyes.

SANITATION

• Skin that becomes wet with liquid tetrahydrofuran should be promptly washed or showered to remove any tetrahydrofuran.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to tetrahydrofuran may occur and control methods which may be effective in each case:

Operation	Controls
Use as a solvent in preparation of printing inks, adhesives, lacquers, and other coatings	General dilution ventilation; personal protective equipment
Use as a Grignard reagent in synthesis of motor fuels, vitamins, hormones, pharmaceuticals, synthetic perfumes, organometallic compounds and insecticides	General dilution ventilation; process enclosure; personal protective equipment
Use as an intermediate in the preparation of various chemicals, including adipic acid, butadiene, polytetramethylene, and acrylic acid	Process enclosure; general dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If tetrahydrofuran gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If tetrahydrofuran gets on the skin, promptly wash the contaminated skin with water. If tetrahydrofuran soaks through the clothing, remove the clothing immediately and flush the skin with water. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of tetrahydrofuran, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When tetrahydrofuran has been swallowed, get medical attention immediately. If medical attention is not immediately available, get the afflicted person to vomit by having him touch the back of his throat with his finger or by giving him syrup of ipecac as directed on the package. This non-prescription drug is available at most drug stores and drug counters and should be kept with emergency medical supplies in the workplace. Do not make an unconscious person vomit.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If tetrahydrofuran is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected, dissolved in alcohol of greater molecular weight than butyl alcohol, and atomized in a suitable combustion chamber. Tetrahydrofuran should

not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.

• Waste disposal method:

Tetrahydrofuran may be disposed of by dissolving in alcohol of greater molecular weight than butyl alcohol, and atomizing in a suitable combustion chamber.

REFERENCES

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RESPIRATORY PROTECTION FOR TETRAHYDROFURAN

Condition	Minimum Respiratory Protection* Required Above 200 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
5000 ppm or less	A gas mask with a chin-style organic vapor canister.
10,000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
20,000 ppm or less	A powered air-purifying respirator with a full facepiece and organic vapor cartridge(s). A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 20,000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Occupational Health Guideline for Toluene

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $C_6H_5CH_3$
- Synonyms: Toluol; phenylmethane; methylbenzene
- Appearance and odor: Colorless liquid with an aromatic odor, like benzene.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for toluene is 200 parts of toluene per million parts of air (ppm) averaged over an eight-hour work shift, and during any such work shift, 300 ppm toluene may not be exceeded except that a peak of 500 ppm toluene is permitted for 10 minutes during the eight-hour work shift. NIOSH has recommended that the permissible exposure limit be reduced to 100 ppm toluene averaged over an eight-hour work shift with a ceiling level of 200 ppm averaged over a ten-minute period. The NIOSH Criteria Document for Toluene should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Toluene can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

- **Effects of overexposure**

1. Short-term Exposure: Toluene may cause irritation of the eyes, respiratory tract, and skin. It may also cause fatigue, weakness, confusion, headache, dizziness, and drowsiness. Peculiar skin sensation may be produced such as a "pins and needles feeling" or numbness. Very high concentrations may cause unconsciousness and death. The liquid splashed in the eye may cause irritation and temporary damage. Inhalation may also cause difficulty in seeing in bright light. If liquid toluene is splashed in the eyes, it will cause temporary irritation.

2. Long-term Exposure: Repeated or prolonged exposure to liquid toluene may cause drying and cracking of the skin.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to toluene.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to toluene at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the central nervous system, liver and kidneys should be stressed. The skin should be examined for evidence of chronic disorders.

—Urinalysis: Since proper kidney function is necessary for biologic monitoring, a urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. The urine should be analyzed for hippuric acid to obtain a background level.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis. Hippuric acid level in urine may be an indicator of the level of toluene exposure.

- **Summary of toxicology**

Toluene vapor causes narcosis. Controlled exposure of human subjects to 200 ppm for 8 hours produced mild fatigue, weakness, confusion, lacrimation, and paresthesia; at 600 ppm for 8 hours there were also euphoria, headache, dizziness, dilated pupils and nausea; at 800

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Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

ppm for 8 hours, symptoms were more pronounced, and after-effects included nervousness, muscular fatigue, and insomnia persisting for several days. Severe but reversible liver and kidney injury occurred in a person who was a glue-sniffer for 3 years; the chief component of the inhaled solvent was toluene (80% V/V); other ingredients were not listed. In workers exposed for many years to concentrations in the range of 80 to 300 ppm, there was no clinical or laboratory evidence of altered liver function. Toluene exposure does not result in the hematopoietic effects caused by benzene; the myelotoxic effects previously attributed to toluene are judged by more recent investigations to be the result of concurrent exposure to benzene present as a contaminant in the commercial toluene used. Most of the toluene absorbed from inhalation is metabolized to benzoic acid, conjugated with glycine in the liver to form hippuric acid, and excreted in the urine; the average amount of hippuric acid excreted in the urine by individuals not exposed to toluene is approximately 0.7 to 1.0 g/l of urine. The liquid splashed in the eyes of two workers caused transient corneal damage and conjunctival irritation; complete recovery occurred within 48 hours. Repeated or prolonged skin contact with liquid toluene has a defatting action, causing drying, fissuring, and dermatitis.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
  1. Molecular weight: 92.1
  2. Boiling point (760 mm Hg): 111 C (231 F)
  3. Specific gravity (water = 1): 0.86
  4. Vapor density (air = 1 at boiling point of toluene): 3.14
  5. Melting point: −95 C (−139 F)
  6. Vapor pressure at 20 C (68 F): 22 mm Hg
  7. Solubility in water, g/100 g water at 20 C (68 F): 0.05
  8. Evaporation rate (butyl acetate = 1): 2.24
- **Reactivity**
  1. Conditions contributing to instability: Containers may burst at elevated temperatures.
  2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
  3. Hazardous decomposition products: Toxic gases and vapors (such as carbon dioxide and carbon monoxide) may be released in a fire involving toluene.
  4. Special precautions: Toluene will attack some forms of plastics, rubber, and coatings.
- **Flammability**
  1. Flash point: 4 C (40 F) (closed cup)
  2. Autoignition temperature: 480 C (896 F)
  3. Flammable limits in air, % by volume: Lower: 1.27; Upper: 7.1
  4. Extinguishant: Carbon dioxide, dry chemical, foam
- **Warning properties**
  1. Odor Threshold: The American National Standards Institute (ANSI) states that "the odor of toluene is detectable by most people at concentrations in the range of 10 to 15 ppm. The odor has little value as a warning property."

  Patty points out that olfactory fatigue occurs rapidly upon exposure to toluene.

  2. Eye Irritation Level: Grant states that "the vapors of toluene cause noticeable sensation of irritation to human eyes at 300 to 400 ppm in air, but even at 800 ppm irritation is slight."

  ANSI reports that "irritation of eyes, mucous membranes, and upper respiratory tract may occur while workers are exposed to low concentrations of toluene. There is a considerable range of variation (100 to 500 ppm) between individuals, some finding any concentration of toluene objectionable. Commercial grades of toluene vary in irritant properties."

  3. Evaluation of Warning Properties: Because of its irritant effects, toluene is judged to have good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

- **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

- **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of toluene. Each measurement should consist of a ten (10) minute sample or series of consecutive samples totalling ten (10) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Peak Above Ceiling Evaluation**

Measurements to determine employee peak exposure should be taken during periods of maximum expected airborne concentration of toluene. Each measurement should consist of a 10-minute sample or a series of consecutive samples totalling 10 minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

- **Method**

Sampling and analyses may be performed by collection of vapors using an adsorption tube with a subsequent desorption of toluene with carbon disulfide and gas

chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure toluene may be used. An analytical method for toluene is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

Methods for Set V" (order number PB 262 524).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid toluene.

• Any clothing which becomes wet with liquid toluene should be removed immediately and not reworn until the toluene is removed from the clothing.

• Clothing wet with toluene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of toluene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the toluene, the person performing the operation should be informed of toluene's hazardous properties.

• Employees should be provided with and required to use splash-proof safety goggles where liquid toluene may contact the eyes.

• Where there is any possibility that employees' eyes may be exposed to toluene, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

• Skin that becomes wet with liquid toluene should be promptly washed or showered with soap or mild detergent and water to remove any toluene.

• Employees who handle liquid toluene should wash their hands thoroughly with soap or mild detergent and water before eating or smoking.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to toluene may occur and control methods which may be effective in each case:

Operation	Controls
Use as a solvent in pharmaceutical, chemical, rubber, and plastics industries; as a thinner for paints, lacquer, coatings, and dyes; as a paint remover; insecticides	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment
Use as starting material and intermediate in organic chemical and chemical synthesis industries	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment
Use in manufacture of artificial leather; fabric and paper coatings; photogravure ink production; spray surface coating; as a diluent (cellulose ester lacquers)	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment
Use as constituent in formulation of automotive and aviation fuels	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If liquid toluene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If liquid toluene gets on the skin, promptly wash the contaminated skin using soap or mild detergent and

water. If liquid toluene soaks through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of toluene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When toluene has been swallowed, get medical attention immediately. Do not attempt to make the exposed person vomit.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If toluene is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a suitable combustion chamber. Toluene should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of toluene vapors are permitted.

• Waste disposal method:

Toluene may be disposed of by atomizing in a suitable combustion chamber.

ADDITIONAL INFORMATION

To find additional information on toluene, look up toluene in the following documents:

• Medical Surveillance for Chemical Hazards
• Respiratory Protection for Chemical Hazards
• Personal Protection and Sanitation for Chemical Hazards
• NIOSH Criteria Document for Toluene (July 1973)

These documents are available through the NIOSH Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

REFERENCES

• American Conference of Governmental Industrial Hygienists: "Toluene," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

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• Union Carbide Corporation, Industrial Medicine and Toxicology Department: *Toxicology Studies – Toluene*, New York, 1970.

RESPIRATORY PROTECTION FOR TOLUENE

Condition	Minimum Respiratory Protection* Required Above 200 ppm
Vapor Concentration	
500 ppm or less	Any chemical cartridge respirator with an organic vapor cartridge(s). Any supplied-air respirator. Any self-contained breathing apparatus.
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
2000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 2000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

Option 1 - Full Display
RECORD# 157 - 1,1,1-TRICHLORDETHANE

0 ADMINISTRATIVE INFORMATION

HAZARDOUS SUBSTANCES DATABANK NUMBER - HSN	157
LAST REVISION DATE - DATE	890505
RECORD LENGTH - RLEN	128268
LAST EDIT	02/09/89 by GCF
LAST RELEASE	02/10/89 by LS
DATE CREATED	ND
REVIEW DATE - RVDT	Reviewed by SRP on 05/20/88
UPDATE HISTORY - UPDT(1)	Field Update on 05/05/89, 1 field added/edited/deleted.
UPDATE HISTORY - UPDT(2)	Complete Update on 02/10/89, 1 field added/edited/deleted.
UPDATE HISTORY - UPDT(3)	Complete Update on 01/26/89, 98 fields added/edited/deleted.
UPDATE HISTORY - UPDT(4)	Complete Update on 09/03/87, 14 fields added/edited/deleted.
UPDATE HISTORY - UPDT(5)	Complete Update on 05/26/87, 17 fields added/edited/deleted.

1 SUBSTANCE IDENTIFICATION

NAME OF SUBSTANCE - NAME	1,1,1-TRICHLORDETHANE
CAS REGISTRY NUMBER - RN	71-55-6
RELATED HSDB RECORDS - RELT(1)	56 [CHLOROFORM]
SYNONYMS - SY(1)	1,1,1-TRICHLOORETHAAN (DUTCH) [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(2)	1,1,1-TRICHLORAETHAN (GERMAN) [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(3)	1,1,1-TRICLORDETANO (ITALIAN) [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(4)	METHYLCHLOROFORM [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(5)	METHYLTRICHLOROMETHANE [CITATION] ** PEER REVIEWED **

1 SUBSTANCE IDENTIFICATION (continued)

SYNONYMS - SY(6)	TRICHLORO-1,1,1-ETHANE (FRENCH) [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(7)	TRICHLOROETHANE [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(8)	TRIELENE [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(9)	CHLOROFORM, METHYL- [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(10)	ETHANE, 1,1,1-TRICHLORO- [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(11)	TCEA [CITATION CHEMICAL PRODUCTS SYNOPSIS: 1,1,1-Trichloroethane, 1985] ** PEER REVIEWED **
SYNONYMS - SY(12)	AI3-02061 [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(13)	Caswell No 875 [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(14)	ALPHA-TRICHLOROETHANE [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(15)	AEROTHENE TT [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(16)	ALGYLEN [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(17)	ALPHA-T [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(18)	BALTANA [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(19)	CF 2 [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(20)	CHLOROETHENE [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(21)	CHLOROETHANE-NU [CITATION] ** PEER REVIEWED **
SYNONYMS - SY(22)	CHLOROTENE [CITATION] ** PEER REVIEWED **

ORIGINAL (Red)

1 SUBSTANCE IDENTIFICATION (continued)

SYNONYMS - SY(40)	Aerothene MM [FLICK. INDUST SOLVENTS HDBK 1985 p 139] ** PEER REVIEWED **
MOLECULAR FORMULA - MF	C2-H3-C13 [CITATION] ** PEER REVIEWED **
WISWESSER LINE NOTATION - WLN	ND
RTECS NUMBER - RTEC	NIOSH/KJ2975000
OHM-TADS NUMBER - OHMN	8100101
SHIPPING NAME/NUMBER - DOT/UN/NA/IMCO - SHPN(1)	UN 2831; 1,1,1-Trichloroethane
SHIPPING NAME/NUMBER - DOT/UN/NA/IMCO - SHPN(2)	IMO 6.1; 1,1,1-Trichloroethane
STCC NUMBER - STCC(1)	49 411 76; 1,1,1-Trichloroethane
EPA HAZARDOUS WASTE NUMBER - HAZN(1)	U226; A toxic waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product.
EPA HAZARDOUS WASTE NUMBER - HAZN(2)	F002; A hazardous waste from nonspecific sources when a spent solvent.
ASSOCIATED CHEMICALS - ASCH(1)	ND

2 MANUFACTURING/USE INFORMATION

METHODS OF MANUFACTURING - MMFG(1)	PREPARED BY ACTION OF CHLORINE ON 1,1-DICHLOROETHANE: SUTTON, PROC SOC A133, 673 (1931); BY CATALYTIC ADDITION OF HCL TO 1,1-DICHLOROETHYLENE ... USA PATENT 2,209,000 (NUTTING, HUSCHER, 1940). [MERCK INDEX. 10TH ED 1983 p 1377] ** PEER REVIEWED **
METHODS OF MANUFACTURING - MMFG(2)	DEHYDROCHLORINATION OF ETHYLENE DICHLORIDE TO VINYL CHLORIDE FOLLOWED BY REACTION WITH HYDROGEN CHLORIDE TO PRODUCE 1,1-DICHLOROETHANE, WHICH IS CHLORINATED; REACTION OF ETHANE & CHLORINE FOLLOWED BY SEPERATION PLUS RECYCLE OF COPRODUCTS. [SRI] ** PEER REVIEWED **

2 MANUFACTURING/USE INFORMATION (continued)

METHODS OF MANUFACTURING - MMFG(3)

1,1,1-Trichloroethane can be produced by refluxing chlorine monoxide with carbon tetrachloride and chloroethane.
[KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT 5(79) 584] ** PEER REVIEWED **

IMPURITIES - IMP(1)

1,1,1-Trichloroethane is available commercially in the USA in technical and solvent grades, which differ only in amt of stabilizer. ... Stabilized grades contain 3-8% stabilizers such as nitromethane, N-methylpyrrole ... butylene oxide, 1,3-dioxolane, and secondary butyl alcohols. Typical specifications are as follows: ... Nonvolatile residues, 0.001% max; water content, 100 mg/kg max; acidity (as HCl), 0.001% max ... & acid acceptance (as NaOH), 0.165% min. ... Specifications for reagent grade ... acidity (as HCl), 0.001% max ... .
[IARC MONOGRAPHS. 1972-PRESENT V20 516 (1979)] ** PEER REVIEWED **

IMPURITIES - IMP(2)

Stabilizing agents which may be present in small amounts include: glycol diesters, ketones, nitriles, dialkyl sulfoxides, dialkyl sulfides, dialkyl sulfites, tetraethyl lead, nitroaliphatic hydrocarbons, 2-methyl-3-butyn-2-ol, tert-butyl alcohol, 1,4-dioxane, dioxolane, sec-butyl alcohol, and monohydric acetylenic alcohols.
[CITATION NIOSH; Criteria Document: 1,1,1-Trichloroethane p.11 (1976) DHEW Pub No 76-184] ** PEER REVIEWED **

IMPURITIES - IMP(3)

Chemical was found by gas chromatography to contain 1,2-dichloroethane, 1,1-dichloroethane, chloroform, carbon tetrachloride, trichloroethylene, 1,1,2-trichloroethane, & vinylidene chloride.
[CITATION Stewart RD et al; Arch Environ Health 19 (4): 467-72 (1969)]
** PEER REVIEWED **

FORMULATIONS/PREPARATIONS - FORM(1)

1,1,1-Trichloroethane is available commercially in the USA in technical & solvent grades, which differ only in amt of stabilizer added to prevent corrosion of metal parts. ... Reagent grade. ...
[IARC MONOGRAPHS. 1972-PRESENT V20 516 (1979)] ** PEER REVIEWED **

2 MANUFACTURING/USE INFORMATION (continued)

FORMULATIONS/PREPARATIONS - FORM(2)	Chlorothene SM, industrial grade [KUNEY. CHEMCYCLOPEDIA 1988 p 120] ** PEER REVIEWED **
FORMULATIONS/PREPARATIONS - FORM(3)	Aerothene TT, aerosol grade [KUNEY. CHEMCYCLOPEDIA 1988 p 120] ** PEER REVIEWED **
FORMULATIONS/PREPARATIONS - FORM(4)	Industrial grade; aerosol grade; general solvent grade, 99.999% grade [KUNEY. CHEMCYCLOPEDIA 1988 p 120] ** PEER REVIEWED **
FORMULATIONS/PREPARATIONS - FORM(5)	Chlorothene VG solvent is a specially inhibited grade of 1,1,1-trichloroethane. Chlorothene SM & Aerothene MM solvents are special grades of 1,1,1-trichloroethane & methylene chloride. [FLICK. INDUST SOLVENTS HDBK 1985 p 139] ** PEER REVIEWED **
MANUFACTURERS - MFS(1)	Dow Chemical USA, Hq, 2020 Dow Center, Midland, MI 48640, (517) 636-1000; Prodn site: PO Box K, Freeport, TX 77541 [CITATION SRI. DIRECTORY OF CHEMICAL PRODUCERS-USA 1987, p.1054] ** PEER REVIEWED **
MANUFACTURERS - MFS(2)	PPG Industries, Inc, (Hq), One PPG Place, Pittsburgh, PA 15272, (412) 434-3131; Prodn site: Chemicals Group, PO Box 1000, Lake Charles, LA 70601 [CITATION SRI. DIRECTORY OF CHEMICAL PRODUCERS-USA 1987, p.1054] ** PEER REVIEWED **
MANUFACTURERS - MFS(3)	Vulcan Materials Co, (Hq), PO Box 7497, Birmingham, AL 35253, (205) 877-3000; Prodn site: Vulcan Chemicals, division, PO Box 227, Geismar, LA 70734 [CITATION SRI. DIRECTORY OF CHEMICAL PRODUCERS-USA 1987, p.1055] ** PEER REVIEWED **
OTHER MANUFACTURING INFORMATION - OMIN(1)	Discontinued 1985, by the Dow Chemical Co, Organics Dept [FARM CHEMICALS HANDBK 1987 C-258] ** PEER REVIEWED **
MAJOR USES - USE(1)	SOLVENT FOR NATURAL & SYNTHETIC RESINS, OILS, WAXES, TAR & ALKALOIDS

2 MANUFACTURING/USE INFORMATION (continued)

MAJOR USES - USE(1)-cont.	[BROWNING. TOX & METAB INDUS SOLV 1965 p 254] ** PEER REVIEWED **
MAJOR USES - USE(2)	DRY CLEANING AGENT [HAMILTON. INDUS TOX 3RD ED 1974 p 285] ** PEER REVIEWED **
MAJOR USES - USE(3)	CLEANING PLASTIC MOLDS [MERCK INDEX. 10TH ED 1983 p 1377] ** PEER REVIEWED **
MAJOR USES - USE(4)	FORMERLY USED WITH ETHYLENE GAS FOR DEGREENING CITRUS FRUITS & POSTHARVEST FUMIGATION OF STRAWBERRIES [FARM CHEM HDBK. 1984 C-231] ** PEER REVIEWED ** ********** Comment - BWK (ORNL) 02/10/88 Data not in latest edition, source 244 **********
MAJOR USES - USE(5)	Solvent for various insecticides /Former use/ [FARM CHEM HDBK. 1984 C-231] ** PEER REVIEWED ** ********** Comment - BWK (ORNL) 02/10/88 Data not in latest edition, source 244 **********
MAJOR USES - USE(6)	CLEANING SOLVENT, ESP FOR ELECTRICAL MACHINERY & PLASTICS; SPOTTING FLUID IN TEXTILE PROCESSING; COMPONENT OF AEROSOL FORMULATIONS; CHEM INT FOR ORG CHEMS (EG, VINYLIDENE CHLORIDE); SOLVENT FOR ADHESIVES & COATINGS; COOLANT & LUBRICANT IN METAL CUTTING OILS; EXTRACTION SOLVENT; COMPONENT OF INKS & DRAIN CLEANERS; SOLVENT FOR PHOTORESIST POLYMERS; SOLVENT IN TEXTILE DYEING. [SRI] ** PEER REVIEWED **
MAJOR USES - USE(7)	The largest other use /besides as cleaning solvent/ for 1,1,1-trichloroethane is in aerosols, in which it acts both as a vapor pressure depressant (making it a good propellant) and as a solvent and carrier for many of the active ingredients used in aerosols. [IARC MONOGRAPHS. 1972-PRESENT V20 518 (1979)] ** PEER REVIEWED **

2 MANUFACTURING/USE INFORMATION (continued)

U.S. PRODUCTION - PROD(5)	(1983) 2.26X10+11 G [SRI] ** PEER REVIEWED **
U.S. PRODUCTION - PROD(6)	The growth rate from 1973-1982 was 3.2% per yr & a growth rate of 3 to 5% per yr is predicted through 1987. [KAVALER. CHEM MARKET REPORTER 1984 p 66] ** PEER REVIEWED **
U.S. PRODUCTION - PROD(7)	(1985) 3.94X10+11 G [CITATION USITC. SYN ORG CHEM-U.S. PROD/SALES 1985 p.268] ** PEER REVIEWED **
U.S. PRODUCTION - PROD(8)	(1987) 725 million of lb (estimated) [KUNEY. CHEMCYCLOPEDIA 1988 p 40] ** PEER REVIEWED **
U.S. PRODUCTION - PROD(9)	(1987) 6.94X10+8 lb [CITATION USITC. SYN ORG CHEM-U.S. PROD/SALES PRELIMINARY 1987] ** PEER REVIEWED **
U.S. IMPORTS - IMPT(1)	(1985) 9.08X10+9 G /based on various trade estimates/ [CITATION CHEMICAL PRODUCTS SYNOPSIS: 1,1,1-Trichloroethane, 1985] ** PEER REVIEWED **
U.S. EXPORTS - EXPT(1)	(1978) 1.80X10+10 G [SRI] ** PEER REVIEWED **
U.S. EXPORTS - EXPT(2)	(1983) 2.58X10+10 G [SRI] ** PEER REVIEWED **
U.S. EXPORTS - EXPT(3)	(1985) 1.81X10+10 G [CITATION BUREAU OF THE CENSUS. U.S. EXPORTS, SCHEDULE E, 1985 p.2-73] ** PEER REVIEWED **
U.S. EXPORTS - EXPT(4)	(1987) 11,420,877 lb [CITATION BUREAU OF THE CENSUS. U. S. EXPORTS, SCHEDULE E, AUG 1987, p. 2-74] ** PEER REVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES

COLOR/FORM - COFO(1)	COLORLESS LIQUID [PATTY. INDUS HYG & TOX 3RD ED VOL2A,2B,2C 1981-82 p 3503] ** PEER REVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

ODOR - ODOR(1)	CHLOROFORM-LIKE ODOR; SWEETISH [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** PEER REVIEWED **
TASTE - TAST(1)	ND
BOILING POINT - BP	74.1 DEG C AT 760 MM HG [WEAST. HDBK CHEM & PHYS 68TH ED 1987-1988. C-266] ** PEER REVIEWED **
MELTING POINT - MP	-30.4 DEG C [WEAST. HDBK CHEM & PHYS 68TH ED 1987-1988. C-266] ** PEER REVIEWED **
MOLECULAR WEIGHT - MW	133.42 [MERCK INDEX. 10TH ED 1983 p 1377] ** PEER REVIEWED **
CORROSIVITY - CORR(1)	Readily corrodes aluminum and aluminum alloys [ITI. TOX & HAZARD INDUS CHEM SAFETY MANUAL 1982 p 536] ** PEER REVIEWED **
CORROSIVITY - CORR(2)	Dry, uninhibited 1,1,1-trichloroethane is not very corrosive to iron or zinc; corrosion rate with iron is (2.54 um/yr ((0.1 mpy) & with zinc (25.4 um/yr ((1.0 mpy). Addition of 7% water incr corrosion rates 254 um/yr ((10.0 mpy) for iron &) 254 um/yr () 10.0 mpy) for zinc. The presence of both water & ethanol incr iron or tin attack at reflux. [KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT 5(79) 728] ** PEER REVIEWED **
CRITICAL TEMPERATURE & PRESSURE - CTP(1)	311.5 deg C; 4.48 MPa [KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT 5(79) 729] ** PEER REVIEWED **
DENSITY/SPECIFIC GRAVITY - DEN	1.3376 AT 20 DEG C/4 DEG C [MERCK INDEX. 10TH ED 1983 p 1377] ** PEER REVIEWED **
DISSOCIATION CONSTANTS - DSC(1)	ND
HEAT OF COMBUSTION - HTC	4700 BTU/LB= 2600 CAL/G= 110X10+5 J/KG [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** PEER REVIEWED **
HEAT OF VAPORIZATION - HTV	8012.7 gcal/gmole

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

HEAT OF VAPORIZATION - HTV -cont.	[WEAST. HDBK CHEM & PHYS 68TH ED 1987-1988. C-671] ** PEER REVIEWED **
OCTANOL/WATER PARTITION COEFFICIENT - OWPC	Log Kow= 2.49 [HANSCH. LOG P DATABASE 1984] ** PEER REVIEWED **
PH - PH	ND
SOLUBILITIES - SOL(1)	SOL IN ACETONE, BENZENE, METHANOL, CARBON TETRACHLORIDE [MERCK INDEX. 10TH ED 1983 p 1377] ** PEER REVIEWED **
SOLUBILITIES - SOL(2)	> 10% in ethanol [WEAST. CRC HDBK DATA ORGANIC CPDS VOL I, II 1985 V1 607] ** PEER REVIEWED **
SOLUBILITIES - SOL(3)	4,400 mg/l in water at 20 deg C [VERSCHUEREN.HDBK ENVIRON DATA ORG CHEM 1983 p 606] ** PEER REVIEWED **
SOLUBILITIES - SOL(4)	Sol in carbon disulfide [ENCYC OCCUPAT HEALTH & SAFETY 1983 p 2213] ** PEER REVIEWED **
SOLUBILITIES - SOL(5)	> 10% in ethyl ether [WEAST. CRC HDBK DATA ORGANIC CPDS VOL I, II 1985 V1 607] ** PEER REVIEWED **
SOLUBILITIES - SOL(6)	> 10% in chloroform [WEAST. CRC HDBK DATA ORGANIC CPDS VOL I, II 1985 V1 607] ** PEER REVIEWED **
SPECTRAL PROPERTIES - SPEC(1)	INDEX OF REFRACTION: 1.43838 AT 20 DEG C/D [MERCK INDEX. 10TH ED 1983 p 1377] ** PEER REVIEWED **
SPECTRAL PROPERTIES - SPEC(2)	IR: 19461 (Sadtler Research Laboratories Prism Collection) [WEAST. CRC HDBK DATA ORGANIC CPDS VOL I, II 1985 V2 587] ** PEER REVIEWED **
SPECTRAL PROPERTIES - SPEC(3)	NMR: 9171 (Sadtler Research Laboratories Spectral Collection) [WEAST. CRC HDBK DATA ORGANIC CPDS VOL I, II 1985 V2 587] ** PEER REVIEWED **
SPECTRAL PROPERTIES - SPEC(4)	MASS: 618 (Atlas of Mass Spectral Data, John Wiley & Sons, New York) [WEAST. CRC HDBK DATA ORGANIC CPDS VOL I, II 1985 V2 587] ** PEER REVIEWED **

3 CHEMICAL AND PHYSICAL PROPERTIES (continued)

OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(7)	Dielectric constant: 7.53 @ 20 deg C (liq) /from table/ [DEAN. HDBK ORGANIC CHEM 1987 4-77] ** PEER REVIEWED **
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(8)	Specific heat @ 20 deg C: 1.004 J/g (liq); 0.782 J/g [KIRK-OTHMER. ENCYC CHEM TECH 3RD ED 1978-PRESENT 5(79) 729] ** PEER REVIEWED **
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(9)	Dipole moment: 1.78 Debyes [WEAST. HDBK CHEM & PHYS 68TH ED 1987-1988. E-59] ** PEER REVIEWED **
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(10)	Heat of capacity @ 25 deg C: 34.4 cal/gmole @ 1 atm (liq); 22.4 cal/gmole @ 1 atm (gas) [WEAST. HDBK CHEM & PHYS 68TH ED 1987-1988. D-173] ** PEER REVIEWED **
OTHER CHEMICAL/PHYSICAL PROPERTIES - OCPP(11)	Chlorothene VG Solvent: Freezing Point - 36.9 deg C; Boiling range @ 760 mm Hg 72-88 deg C; Density 1.232 g/ml @ 20 deg C; Specific gravity 1.327 @ 20 deg C/20 deg C, 1.333 @ 60 deg C/60 deg C, 1.320 @ 25 deg C/25 deg C; Heat of vaporization 7.8 kcal/mol @ 20 deg C, 7.5 kcal/mol @ 50 deg C, 7.1 kcal/mol @ 80 deg C (calculated); Dielectric constant @ 24 deg C 10.0 @ 10+3 cps, 7.0 @ 10+5 cps [FLICK. INDUST SOLVENTS HDBK 1985 p 139] ** PEER REVIEWED **

4 SAFETY AND HANDLING

HAZARDS SUMMARY - HAZS	ND
DOT EMERGENCY GUIDELINES - DOT(1)	Health Hazards: Vapors may cause dizziness or suffocation. Exposure in an enclosed area may be very harmful. Contact may irritate or burn skin and eyes. Fire may produce irritating or poisonous gases. Runoff from fire control or dilution water may cause pollution. [DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-74] ** QC REVIEWED **
DOT EMERGENCY GUIDELINES - DOT(2)	Fire or Explosion: Some of these materials may burn, but none of them ignites readily. Most vapors are heavier than air.

4 SAFETY AND HANDLING (continued)

DOT EMERGENCY GUIDELINES - DOT(2)-cont.	Container may explode in heat of fire. [DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-74] ** QC REVIEWED **
DOT EMERGENCY GUIDELINES - DOT(3)	Emergency Action: Keep unnecessary people away. Stay upwind; keep out of low areas. Self-contained breathing apparatus (SCBA) and structural firefighter's protective clothing will provide limited protection. Isolate for 1/2 mile in all directions if tank car or truck is involved in fire. Remove and isolate contaminated clothing at the site. CALL CHEMTREC AT 1-800-424-9300 FOR EMERGENCY ASSISTANCE. If water pollution occurs, notify the appropriate authorities. [DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-74] ** QC REVIEWED **
DOT EMERGENCY GUIDELINES - DOT(4)	Fire: Small Fires: Dry chemical, CO2 or Halon. Large Fires: Water spray, fog or standard foam is recommended. Cool containers that are exposed to flames with water from the side until well after fire is out. Stay away from ends of tanks. [DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-74] ** QC REVIEWED **
DOT EMERGENCY GUIDELINES - DOT(5)	Spill or Leak: Stop leak if you can do it without risk. Shut off ignition sources; no flares, smoking or flames in hazard area. Small Liquid Spills: Take up with sand, earth or other noncombustible absorbent material. Large Spills: Dike far ahead of liquid spill for later disposal. [DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-74] ** QC REVIEWED **
DOT EMERGENCY GUIDELINES - DOT(6)	First Aid: Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen. In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water. Remove and isolate contaminated clothing and shoes at the site. Use first aid treatment according to the nature of the injury. [DOT. EMERGENCY RESPONSE GUIDEBOOK 1987 G-74] ** QC REVIEWED **

4 SAFETY AND HANDLING (continued)

* FLAMMABLE PROPERTIES - FLAM

FIRE POTENTIAL - FPOT(1)

IT BURNS ONLY IN EXCESS OF OXYGEN OR IN AIR IF A STRONG SOURCE OF IGNITION IS PRESENT.
[ACGIH. DOCUMENTATION OF TLVS 5TH ED 1986 p 382] ** PEER REVIEWED **

FIRE POTENTIAL - FPOT(2)

... Moderately flammable at higher temp.
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-89] ** PEER REVIEWED **

FIRE POTENTIAL - FPOT(3)

An accidental explosion during a welding operation on a 1050 cu m tank holding 70 metric tons of inhibited 1,1,1-trichloroethane under nitrogen to exclude moisture is described. An investigation revealed that the storage tank did not contain any residual contamination from previous products and the 1,1,1-trichloroethane was not contaminated with highly flammable liquids. During the purging of the pipeline, a volume of nitrogen equivalent to approximately 1/2 tank volume had been injected near the base of the tank. The amount of nitrogen added manually, through the roof of the tank, could not be quantified. It was determined that inerting the tank by nitrogen had been insufficient and that a flammable concn of 1,1,1-trichloroethane occupied a portion of the tank near the top and was ignited by heat from welding. Although chlorinated hydrocarbons are often regarded as non-flammable, 1,1,1-trichloroethane for hot work purposes should be treated as highly flammable.
[CITATION Wrightson I, Santon RC; IChE Loss Prev Bull 83: 21 (1988)]
** QC REVIEWED **

NFPA HAZARD CLASSIFICATION - NFPA(1)

Health: 2. 2= Materials hazardous to health, but areas may be entered freely with self-contained breathing apparatus.
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-89] ** PEER REVIEWED **

NFPA HAZARD CLASSIFICATION - NFPA(2)

Flammability: 1. 1= Materials that must be preheated before ignition can occur. Water may cause frothing of liquids ... if it gets below the surface of the liquid and

ORIGINAL (Red)

4 SAFETY AND HANDLING (continued)

* FLAMMABLE PROPERTIES - FLAM	
NFPA HAZARD CLASSIFICATION - NFPA(2)-cont.	turns to steam. ... Water spray gently applied to the surface will cause a frothing which will extinguish the fire. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-89] ** PEER REVIEWED **
NFPA HAZARD CLASSIFICATION - NFPA(3)	Reactivity: 0. 0= Materials which are normally stable even under fire exposure conditions and which are not reactive with water. Normal fire fighting procedures may be used. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-89] ** PEER REVIEWED **
FLAMMABLE LIMITS - FLMT(1)	8.0% and 10.5% [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-89] ** PEER REVIEWED **
FLAMMABLE LIMITS - FLMT(2)	LIMITS OF FLAMMABILITY OF VAPORS OF INHIBITED 1,1,1-TRICHLOROETHANE HAVE BEEN FOUND TO BE 10 TO 15.5% IN AIR WITH HOT WIRE IGNITION. A CONSIDERABLE AMT OF ENERGY IS REQUIRED FOR IGNITION. [PATTY. INDUS HYG & TOX 3RD ED VOL2A,2B,2C 1981-82 p 3503] ** PEER REVIEWED **
FLASH POINT - FLPT(1)	No flash point in conventional closed tester at room temp. ... [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-89] ** PEER REVIEWED **
AUTOIGNITION TEMPERATURE - AUTO	537 deg C, 998 deg F [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-89] ** PEER REVIEWED **
* FIRE FIGHTING INFORMATION - FIRE	
FIRE FIGHTING PROCEDURES - FIRP(1)	DRY CHEMICAL, FOAM, OR CARBON DIOXIDE [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** PEER REVIEWED **
FIRE FIGHTING PROCEDURES - FIRP(2)	Wear self-contained breathing apparatus /when fighting fire/. ... Use water to keep fire-exposed containers cool. Water spray may be used to flush spills away from exposures. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-89] ** PEER REVIEWED **
INTENSITY OF HEAT - INTH(1)	ND

4 SAFETY AND HANDLING (continued)

* FIRE FIGHTING INFORMATION - FIRE

TOXIC COMBUSTION PRODUCTS - TOXC(1)

Toxic and irritating gases are generated in fires.
[CHRIS. HAZARD CHEM DATA VOL. II 1984-5]
** PEER REVIEWED **

OTHER FIRE FIGHTING HAZARDS - OFHZ(1)

Burning rate: (est) 2.9 mm/min
[CHRIS. HAZARD CHEM DATA VOL. II 1984-5]
** PEER REVIEWED **

EXPLOSIVE LIMITS AND POTENTIAL - EXPL(1)

ND

* HAZARDOUS REACTIONS - HAZR

REACTIVITIES & INCOMPATIBILITIES - REAC(1)

Reacts slowly with water, releasing corrosive hydrochloric acid.
[CHRIS. HAZARD CHEM DATA VOL. II 1984-5]
** PEER REVIEWED **

REACTIVITIES & INCOMPATIBILITIES - REAC(2)

Although apparently stable on contact, mixtures with potassium (or its alloys) with a wide range of halocarbons are shock-sensitive and may explode with great violence on light impact. ... Trichloroethane ... /was/ among those investigated.
[BRETHERICK. HDBK REACTIVE CHEM HAZARDS 1985 p 1236] ** PEER REVIEWED **

REACTIVITIES & INCOMPATIBILITIES - REAC(3)

Violent decomp, with evolution of hydrogen chloride, may occur when /it/ ... comes into contact with aluminum or its alloys with magnesium.
[BRETHERICK. HDBK REACTIVE CHEM HAZARDS 1985 p 26] ** PEER REVIEWED **

REACTIVITIES & INCOMPATIBILITIES - REAC(4)

PIPE- & SOLENOID-VALVE ASSEMBLY USED TO TRANSFER NAK /SODIUM POTASSIUM/ HAD BEEN PURGED WITH NITROGEN, THEN FLUSHED WITH WATER. TRICHLOROETHANE, USED SUBSEQUENTLY TO REMOVE TRACES OF WATER, CONTACTED HIDDEN RESIDUE OF NAK /SODIUM POTASSIUM/ IN ONE VALVE AND EXPLOSION ENSUED.
[NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 491M-199] ** PEER REVIEWED **

REACTIVITIES & INCOMPATIBILITIES - REAC(5)

SIDES OF 5,000 PSI AUTOCLAVE WERE BULGED BY EXPLOSIVE REACTION BETWEEN OXYGEN AND 1,1,1-TRICHLOROETHANE WHEN PRESSURIZED

4 SAFETY AND HANDLING (continued)

* HAZARDOUS REACTIONS - HAZR	
REACTIVITIES & INCOMPATIBILITIES - REAC(5) -cont.	MIXT WAS BROUGHT UP TO 100 DEG C & 790 PSI & ALLOWED TO STAND FOR 3 HR. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 491M-149] ** PEER REVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(6)	SEVERAL HALOGENATED SOLVENTS REACTED EXPLOSIVELY WITH LIQ OXYGEN WHEN IGNITED WITH A HIGH ENERGY SOURCE: 1,1,1-TRICHLOROETHANE ... . [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 491M-150] ** PEER REVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(7)	Mixture of liquid oxygen with ... 1,1,1-trichloroethane ... exploded violently when initiated with a blasting cap. [BRETHERICK. HDBK REACTIVE CHEM HAZARDS 1985 p 1350] ** PEER REVIEWED **
REACTIVITIES & INCOMPATIBILITIES - REAC(8)	Reacts violently with nitrogen tetraoxide ... sodium hydroxide. ... [SAX. DANGER PROPS INDUS MATER. 6TH ED 1984 p 2620] ** PEER REVIEWED **
DECOMPOSITION - DCMP(1)	ND
POLYMERIZATION - POLY(1)	ND
OTHER HAZARDOUS REACTIONS - OHAZ(1)	1,1,1-Trichloroethane exploded after heating under oxygen /gas/ at 54 bar and 100 deg C for 3 hr. [BRETHERICK. HDBK REACTIVE CHEM HAZARDS 1985 p 1342] ** PEER REVIEWED **
* WARNING PROPERTIES - WRNP	
ODOR THRESHOLD - ODRT(1)	44 ppm [VERSCHUEREN. HDBK ENVIRON DATA ORG CHEM 1983 p 606] ** PEER REVIEWED **
SKIN, EYE AND RESPIRATORY IRRITATIONS - SERI(1)	Vapors cause a slight smarting of the eyes or respiratory system if present in high concn. Vapors: Irritating to nose and throat. Liquid: irritating to eyes. [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** PEER REVIEWED **
SKIN, EYE AND RESPIRATORY IRRITATIONS - SERI(2)	If the liquid is spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** PEER REVIEWED **

ORIGINAL (Red)

4 SAFETY AND HANDLING (continued)

* PREVENTIVE MEASURES - PRVN

PROTECTIVE EQUIPMENT & CLOTHING - EQUP(1)	ORG VAPOR-ACID GAS CANISTER; SELF-CONTAINED BREATHING APPARATUS FOR EMERGENCIES; NEOPRENE OR POLYVINYL-ALCOHOL-TYPE GLOVES; CHEMICAL SAFETY GOGGLES & FACE SHIELD; NEOPRENE SAFETY SHOES (OR LEATHER SAFETY SHOES PLUS NEOPRENE FOOTWEAR); NEOPRENE OR POLYVINYL ALCOHOL SUIT OR APRONS FOR SPLASH PROTECTION. [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** PEER REVIEWED **
PROTECTIVE EQUIPMENT & CLOTHING - EQUP(2)	The permeation rates of solvents including 1,2-dichloroethane, 1,1,1- or 1,1,2-trichloroethane through protective garment rubber materials are less than 6.36 min/ml, except for unwrinkled Teflon and Viton with greater than 720 and 82 to greater than 144 min/ml, respectively. [CITATION Weeks RW, McLeod MJ; ACS Symp Ser 149 (ISS Chem Hazard Workplace: Meas Control): 235-67 (1981)] ** PEER REVIEWED **
PROTECTIVE EQUIPMENT & CLOTHING - EQUP(3)	Respirator selection (NIOSH): Emergency or planned entry in unknown concn or IDLH conditions: Any self-contained breathing apparatus with a full facepiece & operated in pressure-demand or other positive pressure mode or any supplied-air respirator with full facepiece and operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode. [NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985 p 161] ** PEER REVIEWED **
PROTECTIVE EQUIPMENT & CLOTHING - EQUP(4)	Respirator selection (NIOSH): Escape: Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister or any appropriate escape-type self-contained breathing apparatus. [NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985 p 161] ** PEER REVIEWED **
OTHER PREVENTIVE MEASURES - OPRM(1)	Contact lenses should not be worn when working with this chemical.

4 SAFETY AND HANDLING (continued)

* PREVENTIVE MEASURES - PRVN OTHER PREVENTIVE MEASURES - OPRM(1)-cont.	[NIOSH. NIOSH POCKET GUIDE CHEM HAZ 2ND PRT 1987 p 161] ** PEER REVIEWED **
OTHER PREVENTIVE MEASURES - OPRM(2)	Contact lens use in industry is controversial. A survey of 100 corporations resulted in the recommendation that each company establish their own contact lens use policy. One presumed hazard of contact lens use is possible chemical entrapment. Many authors found that contact lens minimized injury or protected the eye. The eye was afforded more protection from liquid irritants. The authors concluded that soft contact lens do not worsen corneal damage from strong chemicals and in some cases could actually protect the eye. Overall, the literature supports the wearing of contact lenses in industrial environments as part of the standard eye protection, eg face shields; however, more data are needed to establish the value of contact lenses. [CITATION Randolph SA, Zavon MR; J Occup Med 29: 237-42 (1987)] ** PEER REVIEWED **
OTHER PREVENTIVE MEASURES - OPRM(3)	Promptly remove non-impervious clothing that becomes contaminated. [NIOSH. NIOSH POCKET GUIDE CHEM HAZ 5TH PRT 1985 p 161] ** PEER REVIEWED **
OTHER PREVENTIVE MEASURES - OPRM(4)	Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. [CITATION SRP] ** PEER REVIEWED **
STABILITY/SHELF LIFE - SSL(1)	ND
SHIPMENT METHODS AND REGULATIONS - SHIP(1)	Whenever hazardous materials are to be transported, Title 49 CFR, Transportation, Parts 100-180, published by the US Dept of Transportation, contain the regulatory requirements and must be consulted. [CITATION 52 FR 16482 (5/5/87)] ** PEER REVIEWED **

4 SAFETY AND HANDLING (continued)

SHIPMENT METHODS AND REGULATIONS - SHIP(2)	Int'l Air Shipments: Shipping description: 1,1,1-Trichloroethane, IMO 6.1, UN 2831. Label(s) required: Keep away from food. Packaging Instructions: 5.6.605 (passenger); 5.6.612 (cargo). [CITATION] ** PEER REVIEWED **
SHIPMENT METHODS AND REGULATIONS - SHIP(3)	Water shipments: Shipping description: 1,1,1-Trichloroethane, IMO 6.1, UN 2831. Label(s) required: Keep away from food. [CITATION IMDG; International Maritime Dangerous Goods Code; International Maritime Organization (1986)] ** PEER REVIEWED **
SHIPMENT METHODS AND REGULATIONS - SHIP(4)	Shipping description: 1,1,1-Trichloroethane, IMO 6.1, UN 2831. Label(s) required: Keep away from food. Acceptable Modes of transportation: Air, rail, road, and water. [CITATION 52 FR 16660 (5/5/87)] ** PEER REVIEWED **
STORAGE CONDITIONS - STRG(1)	Storage temp: Ambient; Venting: Pressure-vacuum. [CHRIS. HAZARD CHEM DATA VOL. II 1984-5] ** PEER REVIEWED **
STORAGE CONDITIONS - STRG(2)	Store in a cool, dry, well-ventilated location, away from any area where the fire hazard may be acute. [NFPA. FIRE PROTECT GUIDE HAZARD MATLS 9TH ED 1986 49-89] ** PEER REVIEWED **
STORAGE CONDITIONS - STRG(3)	... Do not store in aluminum containers. [ITI. TOX & HAZARD INDUS CHEM SAFETY MANUAL 1982 p 536] ** PEER REVIEWED **
CLEANUP METHODS - CLUP(1)	1. VENTILATE AREA OF SPILL OR LEAK. 2. COLLECT FOR RECLAMATION OR ABSORB IN VERMICULITE, DRY SAND, EARTH, OR A SIMILAR MATERIAL. /1,1,2-TRICHLOROETHANE/ [NIOSH OSHA. OCCUPAT HEALTH GUIDE CHEM HAZARDS. 1981 p 2] ** PEER REVIEWED **
CLEANUP METHODS - CLUP(2)	Environmental considerations, land spill: Dig a pit, pond, lagoon, holding area to contain liquid or solid material. /SRP: If time permits, pits, ponds, lagoons, soak holes, or holding areas should be sealed with an impermeable flexible membrane

4 SAFETY AND HANDLING (continued)

CLEANUP METHODS - CLUP(2)-cont.	liner./ Dike surface flow using soil, sand bags, foamed polyurethane, or foamed concrete; absorb bulk liquid with fly ash, cement powder, or commmercial sorbents. [AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 740] ** PEER REVIEWED **
CLEANUP METHODS - CLUP(3)	Environmental considerations, water spill: Use natural barriers or oil spill travel, use natural deep water pockets, excavated lagoons, or sand bag barriers to trap material at bottom, remove trapped material with suction hoses. [AAR. EMERGENCY HANDLING HAZ MAT SURFACE TRANS 1987 p 740] ** PEER REVIEWED **
DISPOSAL METHODS - DISP(1)	At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices. [CITATION SRP] ** PEER REVIEWED **
DISPOSAL METHODS - DISP(2)	1,1,1,-Trichloroethane should be incinerated after being combined with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove halo acids produced. Dilute with kerosene or fuel oil due to high chlorine content. Evaporation of small amounts was also recommended. ... [UN. TREAT DISPOSAL METHODS WASTE CHEM DATA SERIES NO 5 1985 p 173] ** PEER REVIEWED **
DISPOSAL METHODS - DISP(3)	USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-51 (1982)] Chemical Treatability of 1,1,1-Trichloroethane; Concentration Process: Biological treatment; Chemical Classification: Halocarbon; Scale of Study: Full scale, continuous flow; Type of Wastewater Used: Industrial waste; Results of Study: Effluent concentration; 1.0-20.0 ppb (Survey of 2 municipal wastewater treatment plants). [CITATION] ** PEER REVIEWED **
DISPOSAL METHODS - DISP(4)	USEPA; Management of Hazardous Waste

4 SAFETY AND HANDLING (continued)

DISPOSAL METHODS - DISP(4) -cont.

Leachate, EPA Contract No. 68-03-2766 p.E-105 (1982)] Chemical Treatability of 1,1,1-Trichloroethane; Concentration Process: Stripping; Chemical Classification: Halocarbon; Scale of Study: Literature review; Type of Wastewater Used: Unknown; Results of Study: Air and Steam Strippable. [CITATION] ** PEER REVIEWED **

DISPOSAL METHODS - DISP(5)

A potential candidate for liquid injection incineration at a temperature range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds. A potential candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A potential candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids. [CITATION USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-16 (1981) EPA 68-03-3025] ** PEER REVIEWED **

DISPOSAL METHODS - DISP(6)

USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-105 (1982)] Chemical Treatability of 1,1,1-Chloroethane; Concentration Process: Stripping; Chemical Classification: Halocarbon; Scale of Study: Pilot scale, continuous flow; Type of Wastewater Used: Industrial waste; Results of Study: Overhead flow (% of feed) 2.5 with 0.9:1 reflux to overhead ratio, overhead concentration: 173.4 ppm, bottom concentration: 41.6 ppm; (Water quality: TOC: 9022 ppm, COD (chemical oxygen demand): 15100 ppm, pH: 0.1, acidity: 102312 ppm, Cl: 116, 127 ppm numerous halogens present). [CITATION] ** PEER REVIEWED **

DISPOSAL METHODS - DISP(7)

USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-117 (1982)] Chemical Treatability of 1,1,1-Trichloroethane; Concentration Process: Solvent extraction; Chemical Classification: Halocarbon; Scale of Study: Literature review; Type of Wastewater Used: Unknown; Results of Study: Extractable with alcohols and

4 SAFETY AND HANDLING (continued)

DISPOSAL METHODS - DISP(7) -cont.	aromatics. [CITATION] ** PEER REVIEWED **
DISPOSAL METHODS - DISP(8)	USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-160 (1982)] Chemical Treatability of 1,1,1-Trichloroethane; Concentration Process: Activated carbon; Chemical Classification: Halocarbon; Scale of Study: Literature review; Type of Wastewater Used: Unknown; Results of Study: Reported to be adsorbed. [CITATION] ** PEER REVIEWED **
DISPOSAL METHODS - DISP(9)	USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-192 (1982)] Chemical Treatability of 1,1,1-Trichloroethane; Concentration Process: Resin adsorption; Chemical Classification: Halocarbon; Scale of Study: Laboratory scale; Type of Wastewater Used: Well water; Results of Study: Performance for treatment of water containing several halogens. BV to 33 ppb compound leakage; Virgin: 9000, 23.4 days, 67500 gal treated cu ft Regenerated: 8500, 22.1 days, 63750 gal treated cu ft. Flow: 2 gpm/cu ft (16 BV/hr) regenerated at 37 lb steam/cu ft at 5 psig (lb/sq in gauge). [CITATION] ** PEER REVIEWED **
RADIATION LIMITS AND POTENTIAL - RADL(1)	ND

5 TOXICITY/BIOMEDICAL EFFECTS

TOXICITY SUMMARY - TOXS	ND
TOXIC HAZARD RATING - TXHR(1)	Classification of carcinogenicity: 1) evidence in humans: no adequate data; 2) evidence in animals: inadequate. Overall summary evaluation of carcinogenic risk humans is Group 3: The agent is not classifiable as to its carcinogenicity to humans. /From table/ [IARC MONOGRAPHS. 1972-PRESENT 57 73 (1987)] ** PEER REVIEWED **
EMERGENCY MEDICAL TREATMENT - EMT(1)	ND
ANTIDOTE AND EMERGENCY TREATMENT - ANTR(1)	ND

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR TRICHLOROETHYLENE POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

This guideline summarizes pertinent information about trichloroethylene for workers, employers, and occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

- **Formula:** C_2HCl_3
- **Structure:** $CCl_2 = CHCl$
- **Synonyms:** Acetylene trichloride, ethylene trichloride, TCE
- **Identifiers:** CAS 79-01-6; RTECS KX455000; DOT 1710, label required: "St. Andrew's Cross (X)"
- **Appearance and odor:** Colorless liquid with a sweet odor like chloroform

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 131.38
2. Boiling point (at 760 mmHg): 87.1°C (188°F)
3. Specific gravity (water = 1): 1.46
4. Vapor density (air = 1 at boiling point of trichloroethylene): 4.54
5. Melting point: -86.4°C (-123°F)
6. Vapor pressure at 25°C (77°F): 74.3 mmHg
7. Solubility in water, g/100 g water at 25°C (77°F): 0.00011
8. Evaporation rate (butyl acetate = 1): 6.2
9. Saturation concentration in air (approximate) at 25°C (77°F): 10.1% (101,000 ppm)
10. Ionization potential: 9.47 eV

- **Reactivity**

1. Incompatibilities: Trichloroethylene may react violently with chemically active metals such as barium, lithium, sodium, magnesium, and titanium. Aluminum may react with the free hydrogen chloride in trichloroethylene to produce aluminum chloride, which catalyzes a violent self-accelerating polymerization reaction. Contact with strong caustics may cause the formation of dichloracetylene, a toxic and flammable gas.
2. Hazardous decomposition products: Toxic vapors and gases (e.g., phosgene, hydrogen chloride, and carbon monoxide) may be released in a fire involving trichloroethylene.

- **Flammability**

1. Flash point: 32°C (90°F) (closed cup)
2. Autoignition temperature: 788°C (420°F)
3. Flammable limits in air, % by volume: Lower, 12.5; Upper, 90
4. Extinguishant: Alcohol foam, dry chemical, or carbon dioxide
5. Class IC Flammable Liquid (29 CFR 1910.106), Flammability Rating 1, Practically Nonflammable (NFPA)

- **Warning properties**

1. Odor threshold: 21.4 ppm
2. Eye irritation level: 400 ppm
3. Evaluation of warning properties for respirator selection: Warning properties are not considered in recommending respirators for use with carcinogens.

EXPOSURE LIMITS

The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for trichloroethylene per million parts of air (ppm) as a time-weighted average (TWA) concentration over an 8-hour workshift; the acceptable ceiling concentration is 200 ppm; and the maximum peak concentration above the acceptable ceiling (maximum duration of 5 minutes in any 2-hour period) is 300 ppm. The National Institute for Occupational Safety and Health (NIOSH) recommends that trichloroethylene be controlled and handled as a potential human carcinogen in the workplace and that exposure be minimized to the lowest feasible limit. The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV®) is 50 ppm (270 mg/m³) as a TWA for a normal 8-hour workday and a 40-hour workweek; the ACGIH short-term exposure limit (STEL) is 200 ppm (1,080 mg/m³) (Table 1).

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

Table 1.—Occupational exposure limits for trichloroethylene

	Exposure limits ppm	mg/m³
OSHA PEL TWA	100	—
Acceptable ceiling	200	—
Maximum ceiling (5 min in 2 h)	300	—
NIOSH REL TWA (Ca)*	25	—
ACGIH TLV® TWA	50	270
STEL	200	1,080

* (Ca): NIOSH recommends treating as a potential human carcinogen.

HEALTH HAZARD INFORMATION

• Routes of exposure

Trichloroethylene may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.

• Summary of toxicology

1. *Effects on animals:* Acute inhalation of trichloroethylene by multiple species of animals caused depressed brain function, brain damage, liver and kidney injury, and death due to respiratory failure or cardiac arrest. In rats, rabbits, guinea pigs, and gerbils, chronic inhalation of trichloroethylene caused toxic effects on the nerves, increases in liver and kidney weights, and suppression of growth. Chronic oral administration of trichloroethylene to mice produced cancers of the liver and lungs, and chronic inhalation by female mice produced cancers of the lymph system and lungs.

2. *Effects on humans:* Acute inhalation or ingestion of trichloroethylene has caused reversible peripheral nerve degeneration, injury to the liver and kidneys and to the cardiovascular and gastrointestinal systems, depression of the central nervous system, coma, and sudden death due to respiratory failure, cardiac arrhythmia, or liver or kidney failure. Chronic exposure to trichloroethylene has caused damage to the liver, kidneys, and nervous system. The ingestion of alcohol, caffeine, and some prescription drugs has been found to potentiate the effects of trichloroethylene intoxication. A dermal response seen as a reddening of the face, neck, back, and shoulders (degreaser's flush) has occurred in chronically exposed workers following the ingestion of alcohol. Repeated immersion of the hands into liquid trichloroethylene has caused paralysis of the fingers.

• Signs and symptoms of exposure

1. *Short-term (acute):* Inhalation exposure to trichloroethylene can cause drowsiness, dizziness, headache, blurred vision, incoordination, mental confusion, flushed skin, tremors, nausea, vomiting, fatigue, and cardiac arrhythmia. Irritation of the skin, mucous membranes, and eyes can also occur.

2. *Long-term (chronic):* Exposure can cause headache, cough, double vision, impaired coordination and senses of touch and smell, anxiety, dizziness, giddiness, weakness, tremor, slowness of heartbeat, and intolerance to alcohol. Dryness of the skin, blisters, and dermatitis can also occur.

RECOMMENDED MEDICAL PRACTICES

• Medical surveillance program

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, and morbidity and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• Preplacement medical evaluation

Prior to placing a worker in a job with a potential for exposure to trichloroethylene, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the eyes, skin, liver, kidneys, and cardiovascular, nervous, and respiratory systems. Medical surveillance for respiratory disease should be conducted by using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to trichloroethylene at or below the NIOSH REL. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include chronic diseases of the skin or liver. The physician should obtain baseline values for liver function tests.

• Periodic medical screening and/or biologic monitoring

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that

may be attributed to exposure to trichloroethylene. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the integrity and physiologic function of the eyes, skin, liver, kidneys, and cardiovascular, nervous, and respiratory systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population.

The following tests should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH and ATS: standardized questionnaires and tests of lung function.

• **Medical practices recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population. Because occupational exposure to trichloroethylene may cause diseases of prolonged induction-latency, the need for medical surveillance may extend well beyond termination of employment.

• **Sentinel health events**

1. Acute SHE's include: Contact and/or allergic dermatitis.
2. Delayed-onset SHE's include: Toxic hepatitis.

MONITORING AND MEASUREMENT PROCEDURES

• **TWA exposure evaluation**

Measurements to determine worker exposure to trichloroethylene should be taken so that the TWA exposure is based on a single entire workshift sample or an appropriate number of consecutive samples collected during the entire workshift. Under certain conditions, it may be appropriate to collect several short-term interval samples (up to 30 minutes each) to determine the average exposure level. Air samples should be taken in the worker's breathing zone (air that most nearly represents that inhaled by the worker).

• **Method**

Sampling and analysis may be performed by collecting trichloroethylene vapors with charcoal adsorption tubes followed by desorption with carbon disulfide and analysis by gas chromatography. Detector tubes or other direct-reading devices calibrated to measure trichloroethylene may also be used if available. A detailed sampling and analytical method for trichloroethylene may be found in the *NIOSH Manual of Analytical Methods* (method number S336).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, and other appropriate protective clothing necessary to prevent skin contact with trichloroethylene.

SANITATION

Clothing which is contaminated with trichloroethylene should be removed immediately and placed in sealed containers for storage until it can be discarded or until provision is made for the removal of trichloroethylene from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of trichloroethylene's hazardous properties. Reusable clothing and equipment should be checked for residual contamination before reuse or storage.

A change room with showers, washing facilities, and lockers that permit separation of street and work clothes should be provided.

Workers should be required to shower following a workshift and prior to putting on street clothes. Clean work clothes should be provided daily.

Skin that becomes contaminated with trichloroethylene should be promptly washed with soap and water.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or application of cosmetics, the storage or smoking of tobacco or other smoking materials, or the storage or use of products for chewing should be prohibited in work areas.

Workers who handle trichloroethylene should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to trichloroethylene may occur and control methods which may be effective in each case are listed in Table 2.

Table 2.—Operations and methods of control for trichloroethylene

Operations	Controls
During use as a cleaning solvent in cold cleaning and vapor degreasing operations	Process enclosure, local exhaust ventilation, personal protective equiment
During use as a scouring and cleaning agent in textile processing; during use in the extraction and purification of animal and vegetable oils in food and pharmaceutical industries; during use in chemical synthesis	Process enclosure, local exhaust ventilation
During use in the manufacture of adhesives, anesthetics and analgesics, and cleaning and polishing preparations	Process enclosure, local exhaust ventilation
During use as a fumigant and disintectant for seeds and grains	Local exhaust ventilation, personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures.

• **Eye exposure**

Where there is any possibility of a worker's eyes being exposed to trichloroethylene, an eye-wash fountain should be provided within the immediate work area for emergency use.

If trichloroethylene gets into the eyes, flush them immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• **Skin exposure**

Where there is any possibility of a worker's body being exposed to trichloroethylene, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If trichloroethylene gets on the skin, wash it immediately with soap and water. If trichloroethylene penetrates the clothing, remove the clothing immediately and wash the skin with soap and water. Get medical attention promptly.

• **Rescue**

If a worker has been incapacitated, move the affected worker from the hazardous exposure. Put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILLS AND LEAKS

Workers not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

If trichloroethylene is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. For small quantities of liquids containing trichloroethylene, absorb on paper towels and place in an appropriate container.
3. Large quantities of liquids containing trichloroethylene may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container.
4. Liquids containing trichloroethylene may be collected by vacuuming with an appropriate system.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

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Table 3.—Respiratory protection for trichloroethylene

Condition	Minimum respiratory protection*
Any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown or any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister
	Any appropriate escape-type self-contained breathing apparatus

* Only NIOSH/MSHA-approved equipment should be used.

OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR VINYL CHLORIDE POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

This guideline summarizes pertinent information about vinyl chloride for workers, employers, and occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

- **Formula:** C_2H_3Cl
- **Structure:** $CH_2=CHCl$
- **Synonyms:** Chlorethene, chlorethylene, monochlorethylene, chloroethylene
- **Identifiers:** CAS 75-01-4; RTECS KU9625000; DOT 1086, label required: "Flammable Gas"
- **Appearance and odor:** Colorless gas with a sweet odor

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 62.50
2. Boiling point (at 760 mmHg): -14°C (7°F)
3. Specific gravity (water = 1): 0.9121
4. Vapor density (air = 1 at boiling point of vinyl chloride): 2.15
5. Melting point: -155.7°C (-243.4°F)
6. Vapor pressure at 20°C (68°F): 2,580 mmHg
7. Solubility in water, g/100 g water at 24°C (75°F): 0.11
8. Ionization potential: 9.995 eV

- **Reactivity**

1. Incompatibilities: Atmospheric oxygen and strong oxidizers may react with vinyl chloride to produce peroxide, which can initiate a violent polymerization reaction.
2. Hazardous decomposition products: Toxic vapors and gases (e.g., hydrogen chloride and carbon monoxide) may be released in a fire involving vinyl chloride.
3. Caution: Check valves for leaks.

- **Flammability**

1. Flash point: -78°C (-108°F) (open cup)
2. Autoignition temperature: 472°C (882°F)
3. Flammable limits in air, % by volume: Lower, 3.6; Upper, 33.0
4. Class IA Flammable Liquid Gas (29 CFR 1910.106), Flammability Rating 4 (NFPA)

- **Warning properties**

1. Odor threshold: 3,000 ppm
2. Evaluation of warning properties for respirator selection: Warning properties are not considered in recommending respirators for use with carcinogens.

EXPOSURE LIMITS

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for vinyl chloride is 1 part of vinyl chloride per million parts of air (ppm) as a time-weighted average (TWA) concentration over an 8-hour workshift, and the ceiling concentration which shall at no time be exceeded is 5 ppm as determined in any 15-minute sampling period. The National Institute for Occupational Safety and Health (NIOSH) recommends that vinyl chloride be controlled and handled as a potential human carcinogen in the workplace, and the NIOSH recommended exposure limit (REL) is that exposure be minimized to the lowest feasible limit. The American Conference of Governmental Industrial Hygienists (ACGIH) has designated vinyl chloride as an A1 substance (suspected human carcinogen) with an assigned threshold limit value, TLV® of 5 ppm [10 milligrams of vinyl chloride per cubic meter of air (mg/m^3)] as a TWA for a normal 8-hour workday and a 40-hour workweek (Table 1).

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

Table 1.—Occupational exposure limits for vinyl chloride

	Exposure limits	
	ppm	mg/m³
OSHA PEL TWA	1	—
Ceiling (15 min)	5	—
NIOSH REL (Ca)*	Lowest feasible limit	
ACGIH TLV® TWA (A1a)†	5	10

* (Ca): NIOSH recommends treating as a potential human carcinogen.
† (A1a): Human carcinogen with an assigned TLV.

HEALTH HAZARD INFORMATION

• Routes of exposure
Vinyl chloride may cause adverse health effects following exposure via inhalation, ingestion, or dermal or eye contact.

• Summary of toxicology
1. *Effects on animals:* Acute inhalation of vinyl chloride by multiple species of animals caused central nervous system depression, coma, and death; acute inhalation by dogs also caused cardiac arrhythmias. In mice, rats, and hamsters, chronic inhalation or oral administration of vinyl chloride produced cancers of the liver, kidney, central nervous system, skin, and mammary and ear duct glands.
2. *Effects on humans:* Acute exposure of workers to vinyl chloride has caused narcotic and anesthetic effects. Repeated exposure of workers to vinyl chloride has caused increased blood pressure, decreased blood platelet counts, increased liver enzyme levels, restricted blood flow, bone degeneration in the fingers, liver and spleen enlargement, nervous system disturbances, central nervous system depression, decreased respiratory function, and emphysema. Cancer of the liver has been associated with exposure of workers to vinyl chloride during the polyvinyl chloride production process. Cancers of the lung, brain, skin, nervous system, gall bladder, mouth, and pharynx have also been observed in workers with a history of exposure to vinyl chloride. An increase in fetal mortality has been reported among wives of workers who had been exposed to vinyl chloride.

• Signs and symptoms of exposure
1. *Short-term (acute):* Exposure to vinyl chloride can cause dizziness, light-headedness, nausea, dullness of visual and auditory responses, drowsiness, and unconsciousness. Irritation of the skin and eyes can also occur. Skin contact with the liquid can cause frostbite.
2. *Long-term (chronic):* Exposure to vinyl chloride can cause thickening of the skin, contact and allergic dermatitis, fatigue, coughing and sneezing, abdominal pain, gastrointestinal bleeding, nausea, vomiting, indigestion, diarrhea, jaundice, weight loss, anorexia, and a cold and tingling sensation of the hands and feet.

RECOMMENDED MEDICAL PRACTICES

• Medical surveillance program
Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, morbidity, and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including the employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• Preplacement medical evaluation
Prior to placing a worker in a job with a potential for exposure to vinyl chloride, the physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the skin, liver, kidneys, and cardiovascular, hematopoietic (blood cell forming), nervous, and respiratory systems. Medical surveillance for respiratory disease should be conducted by using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to vinyl chloride. The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include chronic diseases of the liver. The physician should obtain baseline values for serological tests of liver function and markers for infection with Hepatitis B virus.

• Periodic medical screening and/or biologic monitoring
Occupational health interviews and physical examinations

should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to vinyl chloride. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the integrity and physiologic function of the skin, liver, kidneys, and cardiovascular, hematopoietic, nervous, and respiratory systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population. The following test should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH and ATS: standardized questionnaires and test of lung function.

• Medical practices recommended at the time of job transfer or termination

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared to those expected for a suitable reference population. Because occupational exposure to vinyl chloride may cause diseases of prolonged induction-latency, the need for medical surveillance may extend well beyond termination of employment.

• Sentinel health events

Delayed-onset SHE's include: Liver cancer (hemangiosarcoma) and "white finger" (Raynaud's syndrome, secondary to vasculitis)

MONITORING AND MEASUREMENT PROCEDURES

• Method

Sampling and analysis may be performed by collecting vinyl chloride vapors with tandem charcoal tubes followed by desorption with carbon disulfide and analysis by gas chromatography. Direct-reading devices calibrated to measure vinyl chloride may also be used if available. A detailed sampling and analytical method for vinyl chloride may be found in the *NIOSH Manual of Analytical Methods* (method number 1007).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

Workers should be provided with and required to use CPC, gloves, and other appropriate protective clothing necessary to prevent skin contact with vinyl chloride.

SANITATION

Clothing which is contaminated with vinyl chloride should be removed immediately and placed in sealed containers for storage until it can be discarded or until provision is made for the removal of vinyl chloride from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of vinyl chloride's hazardous properties. Reusable clothing and equipment should be checked for residual contamination before reuse or storage.

A change room with showers, washing facilities, and lockers that permit separation of street and work clothes should be provided.

Workers should be required to shower following a workshift and prior to putting on street clothes. Clean work clothes should be provided daily.

Skin that becomes contaminated with vinyl chloride should be promptly washed with soap and water.

The storage, preparation, dispensing, or consumption of food or beverages, the storage or application of cosmetics, the storage or smoking of tobacco or other smoking materials, or the storage or use of products for chewing should be prohibited in work areas.

Workers who handle vinyl chloride should wash their faces, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to vinyl chloride may occur and control methods which may be effective in each case are listed in Table 2.

Table 2.—Operations and methods of control for vinyl chloride

Operations	Controls
During the manufacture of monomer, polymer, copolymer, and terpolymer	Process enclosure, personal protective equipment
During the transfer of monomer to tank cars or polymerization reactors; during maintenance work on tanks or reactors	Local exhaust ventilation, personal protective equipment
During the cleaning of polymerization reaction tanks	Process enclosure, personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures:

• Eye exposure

Where there is any possibility of a worker's eyes being exposed to vinyl chloride, an eye-wash fountain should be

provided within the immediate work area for emergency use.

If vinyl chloride gets into the eyes, flush them immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• **Skin exposure**

Where there is any possibility of a worker's body being exposed to vinyl chloride, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If vinyl chloride gets on the skin, wash it immediately with soap and water. If vinyl chloride penetrates the clothing, remove the clothing immediately and wash the skin with soap and water. Get medical attention promptly.

• **Rescue**

If a worker has been incapacitated, move the affected worker from the hazardous exposure. Put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILLS AND LEAKS

Workers not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

If vinyl chloride is spilled or leaked, the following steps should be taken:

1. Stop the flow of gas. If the source of the leak is a cylinder and the leak cannot be stopped in place, remove the leaking cylinder to an area with local exhaust ventilation and repair the leak or allow the cylinder to empty.
2. Remove all ignition sources.
3. Ventilate area of spill or leak.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 3).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

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Table 3.—Respiratory protection for vinyl chloride

Condition	Minimum respiratory protection*
Any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode
Planned or emergency entry into environments containing unknown or any detectable concentration	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
	Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in pressure-demand or other positive pressure mode
Escape only	Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted canister providing protection against the compound of concern
	Any appropriate escape-type self-contained breathing apparatus

* Only NIOSH/MSHA-approved equipment should be used.

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Occupational Health Guideline for Xylene

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: $C_6H_4(CH_3)_2$
- Synonyms: Commercial xylene (xylol) is a mixture, mostly the meta-isomer. 1) O-xylene, ortho-xylene, 1,2-dimethylbenzene; 2) m-xylene, meta-xylene, 1,3-dimethylbenzene; 3) p-xylene, para-xylene, 1,4-dimethylbenzene
- Appearance and odor: Colorless liquids with aromatic odors (pure p-xylene is a solid below 12.7 C (55 F)).

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for xylene is 100 parts of xylene per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 435 milligrams of xylene per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 100 ppm averaged over a work shift of up to ten hours per day, forty hours per week, with an acceptable ceiling level of 200 ppm averaged over a 10-minute period. The NIOSH Criteria Document for Xylene should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Xylene can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

- **Effects of overexposure**

1. Short-term Exposure: Xylene vapor may cause irritation of the eyes, nose, and throat. At high concentrations, xylene vapor may cause severe breathing difficulties which may be delayed in onset. At high concentrations, it may also cause dizziness, staggering, drowsiness, and unconsciousness. In addition, breathing high concentrations may cause loss of appetite, nausea, vomiting, and abdominal pain. Liquid xylene may be irritating to the eyes and skin. Exposure to high concentrations of xylene vapor may cause reversible damage to the kidneys and liver.

2. Long-term Exposure: Repeated or prolonged exposure to xylene may cause a skin rash. Repeated exposure of the eyes to high concentrations of xylene vapor may cause reversible eye damage.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to xylene.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to xylene at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the central nervous system, eyes, gastrointestinal tract, blood, liver, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders.

—A complete blood count: Xylene has been shown to cause reversible hematopoietic depression in animals. A complete blood count should be performed, including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit.

—Liver function tests: Since liver damage has been observed in humans exposed to xylene, a profile of liver

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function should be obtained by using a medically acceptable array of biochemical tests.

—Urinalysis: Since kidney damage has been observed in humans exposed to xylene, a urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on a biannual basis.

• **Summary of toxicology**

Xylene vapor irritates the eyes, mucous membranes, and skin; at high concentrations it causes narcosis. In animals, xylene causes blood changes reflecting mild toxicity to the hematopoietic system. Repeated exposure of rabbits to 1150 ppm of a mixture of isomers of xylene for 40 to 55 days caused a reversible decrease in red and white cell count and an increase in thrombocytes; exposure to 690 ppm for the same time period caused only a slight decrease in the white cell count. Three painters working in a confined space of a fuel tank were overcome by xylene vapors estimated to be 10,000 ppm; they were not found until 18.5 hours after entering the tank, and one died from pulmonary edema shortly thereafter; the other two recovered completely in 2 days; both had temporary hepatic impairment (inferred from elevated serum transaminase levels) and one of them had evidence of temporary renal impairment (increased blood urea and reduced creatinine clearance). In humans, exposure to undetermined but high concentrations caused dizziness, excitement, drowsiness, incoordination and a staggering gait. Workers exposed to concentrations above 200 ppm complain of anorexia, nausea, vomiting, and abdominal pain. Brief exposure of humans to 200 ppm caused irritation of the eyes, nose, and throat. There are reports of reversible corneal vacuolation in workers exposed to xylene, or to xylene plus other volatile solvents. The liquid is a skin irritant and causes erythema, dryness, and defatting; prolonged contact may cause the formation of vesicles.

CHEMICAL AND PHYSICAL PROPERTIES

Data in the following section are presented for xylene's three isomers: 1) ortho, 2) meta, and 3) para.

• **Physical data**

1. Molecular weight: 106.2

2. Boiling point (760 mm Hg): 1) 144.4 C (292 F); 2) 138.9 C (282 F); 3) 138.3 C (281 F)

3. Specific gravity (water = 1): 1) 0.88; 2) 0.86; 3) 0.86

4. Vapor density (air = 1 at boiling point of xylene): 3.7

5. Melting point: 1) −25 C (−12 F); 2) −48 C (−54 F); 3) 13 C (55 F)

6. Vapor pressure at 20 C (68 F): 1) 7 mm Hg; 2) 9 mm Hg; 3) 9 mm Hg

7. Solubility in water, g/100 g water at 20 C (68 F): 1) 0.00003; 2) 0.00003; 3) 0.00003

8. Evaporation rate (butyl acetate = 1): 1) 0.7; 2) 0.7; 3) 0.7

• **Reactivity**

1. Conditions contributing to instability: Elevated temperatures may cause containers to burst.

2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.

3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving xylene.

4. Special precautions: Xylene will attack some forms of plastics, rubber, and coatings.

• **Flammability**

1. Flash point: 1) 32 C (90 F) (closed cup); 2) 28.9 C (84 F); 3) 27.2 C (81 F)

2. Autoignition temperature: 1) 465 C (869 F); 2) 530 C (986 F); 3) 530 C (986 F)

3. Flammable limits in air, % by volume: Lower: 1) 1.0; 2) 1.1; 3) 1.1; Upper: 1) 6.0; 2) 7.0; 3) 7.0

4. Extinguishant: Foam, carbon dioxide, dry chemical

• **Warning properties**

1. Odor Threshold: Patty states that "the initial odor of 200 ppm has an intensity of approximately 3 and an irritation value of 1. As in most other instances, olfactory fatigue occurs rapidly and the odor is no longer detected at this concentration."

2. Eye Irritation Level: The AIHA *Hygienic Guide* states that "exposure to vapors at 200 ppm caused eye irritation in most of the persons tested. Lesions in the form of fine vacuoles in the cornea of cats exposed to commercial xylene vapors have been observed."

3. Other Information: The *Handbook of Industrial Organic Chemicals* states that xylene "may be irritating to eyes, nose and throat as exposure exceeds threshold limit." The *Hygienic Guide* notes that 200 ppm causes irritation of the nose and throat.

4. Evaluation of Warning Properties: Through its irritant effects, xylene can be detected within three times the permissible exposure limit. For the purposes of this guideline, therefore, xylene is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of xylene. Each measurement

should consist of a ten (10) minute sample or series of consecutive samples totalling ten (10) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure xylene may be used. An analytical method for xylene is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with liquid or solid xylene.

• Clothing contaminated with xylene should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of xylene from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the xylene, the person performing the operation should be informed of xylene's hazardous properties.

• Any clothing which becomes wet with liquid xylene should be removed immediately and non-impervious clothing which becomes contaminated with xylene should be removed promptly and not reworn until the xylene is removed from the clothing.

• Employees should be provided with and required to use splash-proof safety goggles where liquid or solid xylene may contact the eyes.

SANITATION

• Skin that becomes contaminated with xylene should be promptly washed or showered with soap or mild detergent and water to remove any xylene.

• Employees who handle liquid or solid xylene should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to xylene may occur and control methods which may be effective in each case:

Operation	Controls
Use as an intermediate during manufacture of plastics, synthetic fibers, and mixed/pure isomers	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment
Use as diluent or solvent in surface coatings, printing operations, and manufacture of rubber; degreasing agent in plastics and electronics manufacture; in organic synthesis reactions and manufacture of epoxy resins	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment
Use in formulation of insecticides	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment
Use in manufacture of xylene-formaldehyde resins; pharmaceuticals, vitamins, leather; and as a sterilizing agent for cat-gut and in microscopy	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment

Operation	Controls
Use during blending of motor and aviation fuels	Process enclosure; local exhaust ventilation; general mechanical ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If liquid or solid xylene gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• **Skin Exposure**

If liquid or solid xylene gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If liquid or solid xylene penetrates through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation is present after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of xylene, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When xylene has been swallowed, do not induce vomiting. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If xylene is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a suitable combustion chamber. Xylene should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of xylene vapors are permitted.
4. If the solid form, allow to melt and treat as in (3) above.

• Waste disposal method:

Xylene may be disposed of by atomizing in a suitable combustion chamber.

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RESPIRATORY PROTECTION FOR XYLENE (XYLOL)

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
5000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
10,000 ppm or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 10,000 ppm or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

ADDENDUM TWO

DECONTAMINATION

INTRODUCTION

Decontamination is the process of removing or neutralizing contaminants that have accumulated on personnel and equipment. Adequate decontamination is critical to health and safety at hazardous work sites. Decontamination protects:

- Workers against exposure substances that may contaminant and eventually permeate protective clothing
- Respiratory equipment
- Tools
- Vehicles
- Various equipment used on site
- Site personnel by minimizing transfer of contaminants into clean areas
- Against mixing of incompatible chemicals
- Against transport of contaminants from the site

DECONTAMINATION PLAN

A decontamination plan is developed as a part of the Site Safety Plan and established prior to any personnel or equipment entering the area where potential for exposure exists. The decontamination plan should:

- Determine the number and layout of decontamination stations
- Determine the decontamination equipment required
- Determine the appropriate decontamination methods
- Establish procedures to prevent contamination of clean areas
- Establish methods and procedures to minimize worker contact with contaminants during removal of personal protective clothing and equipment (PPE)
- Establish methods for disposing of clothing and equipment not completely decontaminated

The plan should be reviewed/revised whenever the type of personal protective clothing or equipment changes, the site conditions change, or the site hazards are reassessed.

PREVENTION OF CONTAMINATION

The first step in decontamination is to establish operating procedures to minimize contact with the hazardous materials. Methods to accomplish this include:

- Work practices that minimize contact with the hazardous substances
- Use of remote sampling, handling
- Protection of monitoring and sampling instruments by bagging
- Use of disposable outer garments and disposable equipment where appropriate
- Use of covers for equipment and tools with a strippable coating that can be removed during decontamination
- Encasement of the source of contaminants with plastic sheeting or overpacks

In addition, operating procedures should be established that maximize worker protection. Proper procedures for dressing prior to entering the area of contamination will minimize the potential for contaminants to by-pass the protective clothing and escape decontamination.

TYPES OF CONTAMINANTS

Contaminants can be located either on the surface of personal protective equipment (PPE) or permeate into the PPE equipment. Surface contaminants may be easy to detect and remove, but contaminants that have permeated the material are difficult to detect and remove. If contaminants that have permeated a material are not removed by decontamination, they may continue to permeate the material where upon they could cause an unexpected exposure.

Five major factors affect the extent of permeation:

- Contact time. The longer a contaminant remains in contact with the object, the greater the probability for and extent of permeation.

- Concentration. As concentrations of hazardous substances increase, the potential for permeation of PPE increases.

- Temperature. An increase in temperature generally increases the permeation rate of contaminants.

- Size of contaminant molecules and pore space. Permeation increases for smaller sized contaminant molecules.

- Physical state of wastes. As a rule, gases, vapors, and low viscosity liquids tend to permeate more readily than high viscosity liquids or solids.

DECONTAMINATION METHODS

All personnel, clothing, equipment, and samples leaving the contaminated area of a site must be decontaminated to remove any harmful chemicals or infectious organisms that may have adhered to them. Decontamination methods either:

- Physically remove contaminants
- Inactivate contaminants by chemical detoxification or disinfection and sterilization
- Remove contaminants by a combination of physical and chemical actions.

Various decontamination methods are shown in Table A2-1.

In many cases gross contamination can be removed by dislodging or displacement, rinsing, wiping, and evaporation. Contaminants that can be removed by physical means include:

- Loose contaminants. Dusts and vapors that cling to equipment and workers or become trapped in small openings can be removed by water or a liquid rinse. Removal of electrostatically attached materials can be enhanced by coating the clothing or equipment with anti-static solutions (commercially available as wash additives or anti-static sprays).

- Adhering contaminants. Some contaminants may adhere by forces other than electrostatic attraction. Adhesive qualities will vary according to the specific contaminant and the temperature. Contaminants such as glue, cements, resins, and muds have greater adhesive properties and are difficult to remove by physical means. Physical removal for gross contaminants include scraping, brushing, and wiping. Removal of adhesives can be enhanced through solidifying, freezing (i.e., using dry ice or ice water), adsorption or absorption (i.e., with powdered lime or kitty litter), or melting.

- Volatile liquids. Volatile liquid contaminants can be removed from protective clothing and equipment by evaporation followed by a water rinse. The evaporation may be enhanced through the use of steam jets. However, special care must be taken to prevent worker inhalation during an evaporation or vaporization process.

Physical removal of a contaminant should be followed by a wash and rinse process utilizing a cleaning solution(s). Cleaning solutions normally utilize one or more of the following mechanisms:

- Dissolving contaminants. A solvent may be utilized to remove surface contaminants, though compatibility with the equipment being cleaned must be ensured. This is particularly important when decontaminating personal protective clothing constructed of organic materials that may be damaged or destroyed by organic solvents. Additional care must be taken with solvents that may be flammable or potentially toxic. Organic solvents include alcohols, ethers, keytones, aromatics, straight-chain alkanes, and common petroleum products.

  Halogenated solvents generally are incompatable with PPE and are toxic. Their use should be restricted only to extreme cases where other cleaning agents are ineffective.

Table A2-2 provides a general guide to the solubility of several contaminant categories in four types of solvents: water, dilute acids, dilute bases, and organic solvents. Because of the potential hazards, decontamination using chemicals should be done only if recommended by an industrial hygienist or qualified health professional.

- Surfactants. Surfactants augment the physical cleaning methods by reducing adhesion forces between contaminants and the surface being cleaned and reducing redeposition. Household detergents are among the most common surfactants. Some detergents can be used with organic solvents to improve the dispersal and dissolving of the contaminant into the solvent.

- Solidification. Solidifying liquid or gel contaminants can enhance their physical removal. The mechanisms of solidification include: moisture removal by the use of aborbents (i.e., ground clay or powdered lime); chemical reactions through polymerization catalysts and chemical reagents; freezing by use of ice water.

- Rinsing. Rinsing removes contaminants through dilution, physical attraction, and solublization. Multiple rinses with clean solutions remove more contaminants than a single rinse with the same volume of solution.

- Disinfection and sterilization. Chemical disinfectants are a practical means of inactivating infectious agents. However, standard sterilization techniques are impractical for large equipment and for PPE equipment. Therefore, disposable PPE is recommended for use with infectious agents.

Numerous factors such as cost, availability, and ease of implementation influence the selection of a decontamination method. From a health and safety standpoint, two key questions must be addressed:

- Is the decontamination method effective for the specific substances present?

- Does the method itself pose any health or safety hazards?

TESTING THE EFFECTIVENESS OF DECONTAMINATION

Decontamination methods vary in their effectiveness for removing different substances. The effectiveness of any decontamination method should be assessed at the beginning and periodically through the lifetime of the program. The following methods can be useful in assessing the effectiveness of decontamination.

- Visual observation. In some cases, effectiveness can be estimated by visual observation in natural light (i.e., discolorations, stains, corrosive effects, visible dirt or alterations in clothing fabric) or by ultraviolet light (UV) (i.e., polycyclic aromatic hydrocarbons may be common in many refined oils and solvent wastes, fluoresce when exposed to UV light) which can be used to detect contamination on the skin, clothing, and equipment. Care when utilizing UV light on the skin must be taken as certain areas of the skin may naturally fluoresce and UV light can increase the risk of skin cancer and eye damage. A qualified health professional should be consulted prior to the use of UV light at a site.

- Wipe sampling. Wipe testing provides after-the-fact information concerning the effectiveness of decontamination. The procedure can be accomplished by using a dry or wet cloth, glass fiber filter paper, or a swab which is wiped over the potentially contaminated object and analyzed in a laboratory. Both the inner and outer surfaces of the clothing, equipment, and skin may be tested in this manner.

- Cleaning solution analysis. Another means by which the effectiveness of decontamination can be tested is by analyzing the contaminants in the cleaning solutions. Elevated concentrations in the final rinse may indicate additional cleaning and rising are required.

- Testing for permeation. To test for the permeation of chemical contaminants requires that swatches of the clothing material be submitted for analysis.

DECONTAMINATION FACILITY DESIGN

The decontamination facility design is dependent on the level and types of decontamination procedures required and on site specific factors. The decontamination process must provide for a series of procedures performed in a specific sequence. An example of an orderly procedure for decontamination may include:

- Equipment drop area
- Outer, more heavily contaminated items such as outer boots and gloves decontaminated and removed first
- Decontamination and removal of inner less contaminated items such as shirts and pants
- Removal of respiratory protective device followed by last inner gloves

Each step should be performed at separate and segregated stations to prevent contamination cross over. In addition, each step should be arranged in order of decreasing contamination. Minimum and maximum decontamination layouts are shown in Figures 9-1, 9-2 and 9-3 in Section 9.0.

DECONTAMINATION EQUIPMENT SELECTION

Table A2-3 lists recommended equipment for decontamination of personnel, personal protective equipment, and equipment. In selecting decontamination

equipment, consider whether the equipment itself can be decontaminated for reuse or can be easily disposed. Table A2-4 lists types of equipment that may be used for large equipment and vehicles. Other types of equipment listed in these tables may also be appropriate in certain situations.

Equipment used for DECON must be decontaminated and/or disposed of properly. Buckets, brushes, clothing, tools, and other contained equipment should be collected, placed into containers, and labeled. In addition, all spent solutions and wash water should be collected and disposed of properly.

PERSONAL PROTECTION

Personal protection of workers in the DECON area must be addressed. In some cases the PPE required may be identical to that worn by those individuals exiting the work zone. However, in most cases the level of protection required in the DECON area is one step lower. The level of protection will vary with the type of DECON equipment used. Utilization of a steam jet may require different respiratory protection due to the moisture levels produced or the cleaning solutions used, and wastes removed during decontamination may generate harmful vapors.

All decontamination workers are in a contaminated area and must themselves be decontaminated before entering the clean support zone. The extent of their decontamination should be determined by the types of contaminants they may have contacted and the type of work they perform.

EMERGENCY DECONTAMINATION

In addition to routine decontamination procedures, emergency decontamination procedures must be established. In an emergency, the primary concern is to prevent the loss of life or severe injury to site personnel. Should immediate medical attention be required to save a life, decontamination should be delayed until the victim is stabilized. However, if decontamination can be performed without interfering with first aid or life saving techniques, or

should a worker be contaminated with an extremely toxic or corrosive material that has the potential to cause severe injury or loss of life, decontamination must be performed immediately. If an emergency due to a heat-related illness develops, protective clothing should be removed from the individual to reduce heat stress. During an emergency, provision must also be made for protecting medical personnel and disposing of contaminated clothing and equipment.

TABLE A2-1

SOME DECONTAMINATION METHODS

REMOVAL

Contaminant Removal

Water rinse, using pressurized or gravity flow.

Chemical leaching and extraction.

Evaporation/vaporization.

Pressurized air jets.

Scrubbing/scraping. Commonly done using brushes, scrapers, or sponges and water-compatible solvent cleaning solutions.

Steam jets.

Removal of Contamination Surfaces

Disposal of deeply permeated materials, e.g., clothing, floor mats, and seats.

Disposal of protective coverings/coatings.

INACTIVATION

Chemical Detoxification

Halogen stripping.

Neutralization.

Oxidation/reduction.

Thermal/degradation.

Disinfection/Sterlization

Chemical disinfection.

Dry heat sterilization.

Gas/vapor sterilization.

Irradiation.

Steam sterilization.

TABLE A2-2

GENERAL GUIDE TO SOLUBILITY OF CONTAMINANTS
IN FOUR SOLVENT TYPES

Solvent	Soluble Contaminants
Water	Low-chain hydrocarbons. Inorganic compounds. Salts. Some organic acids and other polar compounds.
Dilute Acids	Basic (caustic) compounds. Amines. Hydrazines.
Dilute Bases For example: -detergent -soap	Acidic compounds. Phenols. Thiols. Some nitro and sulfonic compounds.
Organic Solvents[a] For example: -alcohols -ethers -ketones -aromatics -straight-chain alkanes (e.g., hexane) -common petroleum products (e.g., fuel oil, kerosene)	Nonpolar compounds (e.g., some organic compounds).

[a]WARNING: Some organic solvents can permeate and/or degrade the protective clothing.

TABLE A2-3

SOME RECOMMENDED EQUIPMENT FOR DECONTAMINATION OF PERSONNEL AND PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT

Drop cloths of plastic or other suitable materials on which heavily contaminated equipment and outer protective clothing may be deposited.

Collection containers, such as drums or suitably lined trash cans, for storing disposable clothing and heavily contaminated personal protective clothing or equipment that must be discarded.

Lined box with absorbents for wiping or rinsing off gross contaminants and liquid contaminants.

Large galvanized tubs, stock tanks, or children's wading pools to hold wash and rinse solutions. These should be at least large enough for a worker to place a booted foot in, and should have either no drain or a drain connected to a collection tank or appropriate treatment system.

Wash solutions selected to wash off and reduce the hazards associated with the contaminants.

Rinse solutions selected to remove contaminants and contaminated wash solutions.

Long-handled, soft-bristled brushes to help wash and rinse off contaminants.

Paper or cloth towels for drying protective clothing and equipment.

Lockers and cabinets for storage of decontaminated clothing and equipment.

Metal or plastic cans or drums for contaminated wash and rinse solutions.

Plastic sheeting, sealed pads with drains, or other appropriate methods for containing and collecting contaminated wash and rinse solutions spilled during decontamination.

Shower facilities for full body wash or, at a minimum, personal wash sinks (with drains connected to a collection tank or appropriate treatment system).

Soap or wash solution, wash cloths, and towels for personnel.

Lockers or closets for clean clothing and personal item storage.

TABLE A2-4

SOME RECOMMENDED EQUIPMENT FOR
HEAVY EQUIPMENT AND VEHICLE DECONTAMINATION

Storage tanks of appropriate treatment systems for temporary storage and/or treatment of contaminated wash and rinse solutions.

Drains or pumps for collection of contaminated wash and rinse solutions.

Long-handled brushes for general exterior cleaning.

Wash solutions selected to remove and reduce the hazardous associated with the contamination.

Rinse solutions selected to remove contaminants and contaminated wash solutions.

Pressurized sprayers for washing and rinsing, particularly hard-to-reach areas.

Curtains, enclosures, or spray booths to contain splashes from pressurized sprays.

Long-handled brushes, rods, and shovels for dislodging contaminants and contaminated soil caught in tires and the undersides of vehicles and equipment.

Containers to hold contaminants and contaminated soil removed from tires and the undersides of vehicles and equipment.

Wash and rinse buckets for use in the decontamination of operator areas inside vehicles and equipment.

Brooms and brushes for cleaning operator areas inside vehicles and equipment.

Containers for storage and disposal of contaminated wash and rinse solutions, damaged or heavily contaminated parts, and equipment to be discarded.

ADDENDUM THREE

HNU PI 101 PHOTOIONIZER CALIBRATION AND FOXBORO ORGANIC VAPOR ANALYZER

CALIBRATION OF THE HNU PI 101 ANALYZER

A complete maintenance schedule is performed on the HNU analyzer by ECKENFELDER INC.'s Instrumentation Specialist (IS). This schedule includes in-house calibration and operation prior to field use, and cleaning, calibration, and operational checks upon return. However, field calibration is mandatory on the species and concentration range required by the individual operator. The following steps should be performed to properly calibrate the HNU analyzer, utilizing isobutylene for calibration with the 10.2 eV probe. Ambient concentrations of volatile organic compounds are reported as ppm benzene. The process of calibration will be performed outside of any suspect or contaminated area. Calibration of the HNU analyzer will be conducted at the beginning of each day, when the range is changed, or if problems with the instrument are encountered.

Step 1 • Set the range setting at X10 (this range will provide accurate values on the X1 range also).

Step 2 • Attach the 10.2 probe to the read-out assembly, insuring red interlocking switch is depressed.

Step 3 • Attach the isobutylene gas cylinder regulator to the HNU 10.2 probe.

Step 4 • Adjust the flow from the regulator so that only a little excess flow is registered at the flowmeter. (Insures HNU sees calibration gas at atmospheric pressure and ambient temperature). NOTE: If calibration gas cylinder reads 300 psi or less, the cylinder should not be used as it may cause concentration variations.

Step 5 • Turn function switch to BATT and ensure the needle is in green area. (If not, battery requires recharging.)

Step 6 • Turn function switch to STANDBY. Set zero point with zero set control.

Step 7 • For 0 to 20 or 0 to 200 range, turn function switch to that setting and note meter reading. Adjust SPAN control to read the ppm concentration of the calibration gas which is noted on each cylinder of calibration gas.

Recheck zero setting (step 6). If readjustment is required, repeat step 7. (This gives a two-point calibration, zero and the calibration gas standard point).

Step 8 • Calibration checking:

-- Immediately after calibration, make a reading using the isobutylene standard. The concentration as stipulated on the isobutylene cylinder should be reflected.

-- Periodic checks using the isobutylene standard during the period of HNU operation can provide a rapid calibration check in the field. The field results should compare with that concentration found during initial calibration check.

Any problems encountered with calibration should warrant contact with the Corporate Health and Safety Coordinator or Instrumentation Specialist. Under no circumstances will the HNU be utilized in the field until all problems have been resolved, and proper calibration accomplished.

PROCEDURES FOR THE FIELD OPERATIONS OF AN OVA (ORGANIC VAPOR ANALYZER)

A maintenance schedule is performed on the Organic Vapor Analyzer (OVA) by ECKENFELDER INC.'s Instrumentation Specialist. This schedule includes in-house calibration and operation, primary filter cleaning, secondary filter cleaning, burner assembly filter cleaning, exhaust flame aerator cleaning, and sampling fixture cleaning. Further maintenance performed, as specified by the manufacturer, includes the hydrogen tank supply and refill valves, and air sampling system maintenance.

Field calibration of the OVA 128 is mandatory on the species and concentration range required by the individual operator. While at the time of manufacture the unit is calibrated to mixtures of methane in air, for precise analysis it is necessary to recalibrate with the specific compound of interest. To operate in the survey mode for the detection of total organic vapors, a known sample of methane in air in the range of 90 to 100 ppm is used.

The following steps should be performed to properly calibrate the OVA 128, utilizing methane or a gas specific for the species of interest. The process of calibration is performed outside of any suspect or contaminated area and should be performed once each morning and afternoon before active use. Additional calibration should be conducted whenever the range is changed or if problems with the instrument are encountered.

Step 1 Obtain a sample of methane in air in the range of 90 to 100 ppm.

Step 2 Start instrument and allow to operate for 15 minutes; set Calibrate Switch to X10.

Step 3 Zero background by use of the Calibrate Adjust (zero) knob.

Step 4 Draw a sample of the calibration gas into the instrument.

Step 5 The gas select knob on the panel is then used to set the readout meter indication to correspond to the concentration of the calibration gas mixtures. Record the Gas Select knob setting for future reference.

Note: Other air and sample gas mixtures may be used and calibrated in the same manner as that for air and methane. Recording the Gas Select knob setting for each will provide a library of references should that particular gas require investigation. To investigate a gas following calibration, turn the Gas Select knob from that of methane to that previously recorded for the species of interest determined during calibration.

Should the OVA encounter extremely high (>1,000 ppm) concentrations of a gas, or should the detector be contaminated by an oily compound, a more extensive calibration process may be required. Prior to beginning this mode of calibration, check the calibration by the previous five steps. Should the Gas Select knob not require adjustment from the previous setting recorded, the following calibration procedure will not be required.

To calibrate the OVA after a major malfunction, following an encounter with high concentration, and/or after the detector is cleaned, the succeeding steps must be followed:

Step 1 Place instrument into normal operation with the Calibrate Switch set to X10 and the Gas Select control set to 300.

Step 2 Adjust the meter to zero by use of the Calibrate Adjust (zero) knob.

Step 3 Introduce a methane sample of a known concentration (between 90 and 100 ppm, not to exceed 100 ppm) and adjust the R-32 trimpot (found behind the main unit frame following removal from the blue case) so that the meter reading corresponds to the known calibration sample. The instrument gain for methane has now been set at a reference number of 300.

Step 4 Turn off the Hydrogen Supply Value to put out flame.

Step 5 Leave the Calibrate Switch on X10 position and use the Calibrate Adjust (zero) knob to adjust the meter reading to 4 ppm.

Step 6 Place the Calibrate Switch into the X1 position and using the trimpot R-31 (found next to R-32), adjust the meter reading to 4 ppm.

Step 7 Move the Calibrate Switch to the X10 position and using the Calibrate Adjust (zero) knob, adjust the meter to read 40 ppm.

Step 8 Move the Calibrate Switch to the X100 position, and using the trimpot R-33 (found next to R-32), adjust the meter reading to 40 ppm.

Step 9 Move the Calibrate Adjust (zero) knob to adjust the meter reading to zero.

The unit is now balanced from range to range, calibrated to methane, and ready to be placed into normal service.

Any problems encountered during either calibration process will warrant contact with the Corporate Health and Safety Officer or the Instrumentation Specialist. Under no circumstances will the OVA 128 be utilized in the field until all problems have been resolved, and proper calibration accomplished.